Automotive Trade Training

RAY F. KUNS

SIGILLVM · VNIVERSITATIS · CALIFORNIENSIS
FIAT LVX
MDCCCLXVIII
EX LIBRIS
University Farm
TL145
K8

UNIVERSITY OF CALIFORNIA LIBRARY

THIS BOOK IS DUE ON THE LAST DATE
STAMPED BELOW

NOV 2 8 1937

NOV 5 1953

5m-10,'22

Digitized by the Internet Archive
in 2007 with funding from
Microsoft Corporation

http://www.archive.org/details/automotivetradet00kunsrich

AUTOMOTIVE TRADE TRAINING

AUTOMOTIVE TRADE TRAINING

RAY F. KUNS

Principal Automotive Trade School
Cincinnati, Ohio

BRUCE - MILWAUKEE

THE BRUCE PUBLISHING COMPANY
MILWAUKEE, WISCONSIN

Copyright I922
THE BRUCE PUBLISHING COMPANY

Printed in the United States
of America

INTRODUCTION

As may be gathered from its title, this book has been worked out with one main idea in mind, namely, to present a clear-cut and concise explanation of the automotive-trades theory and practice, to all who are seeking information in this field. Another purpose hardly less important was to bring all this desirable information under one cover. Just as the mechanic must work with the tools at hand, he is very often required to do the job with the information at hand. The various trades are so interrelated that it has not seemed wise to try to treat each one separately.

The automotive trades vary widely in content. The automobile repair man makes the usual repairs and installs the new parts necessary to the machinery of the automobile. The automotive electrician handles the repairs and new installation of the electrical equipment. The storage battery man recharges and repairs the battery equipment. The vulcanizer installs new and repairs old tire equipment The radiator repair man cares for the radiator and other sheet metal repairs. Other phases of the automotive trades work are likewise special fields.

However, it is frequently the case that one concern or even one man will be found doing all varieties or several combinations of automotive trades work. The owner is frequently desirous of doing the repair work on his car. With these facts in mind the author has attempted to organize the vast amount of information and to arrange the essential processes so as to give correct trade practice.

Correct trade practice is very largely a fixed matter. Not all mechanics use the same methods, but the results arrived at must not vary. For this reason the theory of design and the construction of the parts or units under repair must be understood. Repairs must be carefully made in order to be right. The author is not particularly concerned as to whether the repairs are made by the owner of the car, or by the repair man to whom the owner has entrusted the work. His concern is rather in helping each to do the work in a manner which will result in a safe, satisfactory and permanent job. In other words, this volume is dedicated to the teaching of high standards of workmanship.

No attempt has been made to show methods of repair and overhaul on every make of automobile, but every type of equipment has been treated. The description of design and operation is given in the first part of each chapter and the usual line of repair work for that type of equipment appears in the latter part of the chapter. To learn what information is available on any type of equipment, the index should be consulted with reference to both job sheets and general information.

The author is desirous of acknowledging the splendid help received from his associates on the faculty of the Cincinnati Automotive Trade School. Each one deserves commendation for his help in his own particular line: Mr. E. O. Bathgate on chassis; Messrs. Frank Buerkle and William Schatz on engines; Mr. Frank Bechtold on service; Mr. Fred Schuster on battery work; Mr. Chas. Shields on vulcanizing; Messrs. Floyd E. Hauss, Roy E. Cahall, Fred Schaeperklaus and Walter von Schlichten on starting, lighting and ignition.

Acknowledgment is also due to the following manufacturers of automotive apparatus and equipment for their splendid co-operation:

Akron-Williams Co., Akron, O.
The Allen Motor Car Company, Columbus, Ohio.
American Bosch Magneto Corp., Detroit, Mich.
Apperson Bros. Automobile Co., Kokomo, Ind.
Atwater Kent Manufacturing Co., Philadelphia, Pa.
The Borg & Beck Co., Chicago, Ill.
The Buda Co., Harvey, Ill.
Buffalo Forge Co., Buffalo, N. Y.
Buick Motor Co., Flint, Mich.
Byrne, Kingston & Co., Kokomo, Ind.
Cadillac Motor Car Co., Detroit, Mich.
Chandler Motor Car Co., Cleveland, Ohio
Cincinnati Storage Battery Co., Cincinnati, Ohio.
Cole Motor Car Co., Indianapolis, Ind.
Connecticut Telephone & Electric Co., Meriden, Conn.
Continental Motors Corp., Detroit, Mich.
Dodge Bros., Detroit, Mich.
Eisemann Magneto Corp., Brooklyn, N. Y.
Dyneto Electric Corp., Syracuse, N. Y.
The Electric Storage Battery Co., Philadelphia, Pa.
Essex Motors, Detroit, Mich.
Ford Motor Co., Detroit, Mich.
Franklin Automobile Co., Syracuse, N. Y.
Gemmer Manufacturing Co., Detroit, Mich.
General Electric Co., Schenectady, N. Y.
The Goodyear Tire & Rubber Co., Akron, Ohio.
Gray & Davis, Inc., Boston, Mass.
Greenfield Tap & Die Corp., Greenfield, Mass.
The Haynes Automobile Co., Kokomo, Ind.
Hudson Motor Car Co., Detroit, Mich.
The K-W Ignition Co., Cleveland, Ohio.
The Kelly-Springfield Motor Truck Co., Springfield, Ohio.
King Motor Car Co., Detroit, Mich.
The Leece-Neville Co., Cleveland, Ohio.
The Lavine Gear Co., Milwaukee, Wis.
Maxwell Motor Sales Corp., Detroit, Mich.
The Nash Motors Co., Kenosha, Wis.
National Lamp Works, Cleveland, Ohio.
National Motor Car & Vehicle Corp., Indianapolis, Ind.
Nordyke & Marmon Co., Indianapolis, Ind.
North East Electric Co., Rochester, N. Y.
Oakland Motor Car Co., Pontiac, Mich.
Oxweld-Acetylene Co., Chicago, Ill.
Packard Motor Car Co., Detroit, Mich.
The Park Drop Forge Co., Cleveland, Ohio.
The Peerless Motor Car Co., Cleveland, Ohio.
The Pierce-Arrow Motor Car Co., Buffalo, N. Y.
The Pierce Governor Co., Anderson, Ind.
Remy Electric Div., General Motors Co., Anderson, Ind.
Reo Motor Car Co., Lansing, Mich.
Republic Motor Truck Co., Alma, Mich.
Rochester Motors Co., Inc., Rochester, N. Y.
Ross Gear & Tool Co., Lafayette, Ind.
The Simms Magneto Co., East Orange, N. J.
Splitdorf Electrical Co., Newark, N. J.
Standard Steel Car Co., Pittsburgh, Pa.
Stearns-Knight Motor Car Co., Cleveland, Ohio.
Stromberg Motor Devices Co., Chicago, Ill.
The Studebaker Corp., South Bend, Ind.
Stutz Motor Car Co., Indianapolis, Ind.
The Tillotson Manufacturing Co., Toledo, Ohio.
Thermoid Rubber Co., Trenton, N. J.
The Timken-Detroit Axle Co., Detroit, Mich.
Torbensen Axle Co., Cleveland, Ohio.
The Timken Roller Bearing Co., Canton, Ohio.
Wagner Electric Mfg. Co., St. Louis, Mo.
Weaver Mfg. Co., Springfield, Ill.
Westinghouse Electric & Mfg. Co., Springfield, Mass.
Weston Electrical Instrument Co., Newark, N. J.
The Wheeler-Schebler Carburetor Co., Indianapolis, Ind.
Willard Storage Battery Co., Cleveland, Ohio.
Willys-Overland, Inc., Toledo, Ohio.
The Zenith Carburetor Co., Detroit, Mich.

TABLE OF CONTENTS

AUTOMOTIVE TRADE TRAINING

CHAPTER 1

FRAMES AND SPRINGS

Chassis, as the term is applied to their product by the manufacturers, has come to mean all details of the motor car, excepting only the body. Standard manufacturing practice is the building of one type of chassis, but fitting many types of bodies onto it.

The line of flow of power, or power transmission, should be learned early by the student, in order that he may understand the value and duties of the various units of construction. When a part is mentioned in his hearing he should have in mind instantly the location of that part or unit, or at least its relative position in general design. He should have in mind as well its purpose. For instance, practically all modern motor cars are equipped with gasoline engines. Power is transmitted to the crankshaft and flywheel of the engine, thence to the clutch, to the transmission, to the universals and propellor shaft, to the differential, to the rear axle shafts, to the wheels, and to the road.

It must be understood that these units are always in the line of flow of power. Design may vary in minor details but that need occasion no confusion. It is useless to study about any unit used in the transmission of power if its position and interrelation with other units are not known. With these points in mind any unit may be studied in detail and its functions observed.

Frames.—The frame is so well designed and constructed in most cases that it rarely needs repairs more than heating and straightening parts of it thrown out of position due to wrecks or other mishaps. Occasionally brackets need to be replaced and at times even side or cross members. In cases of cracks in the frame, they are often welded without removing either the body or the engine, or other units from the frame.

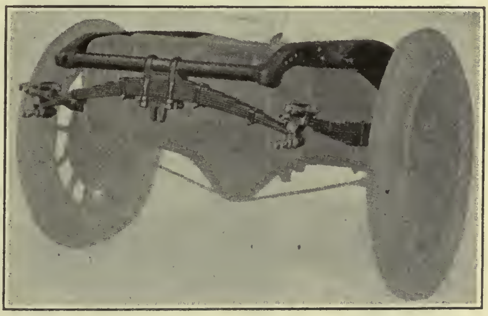
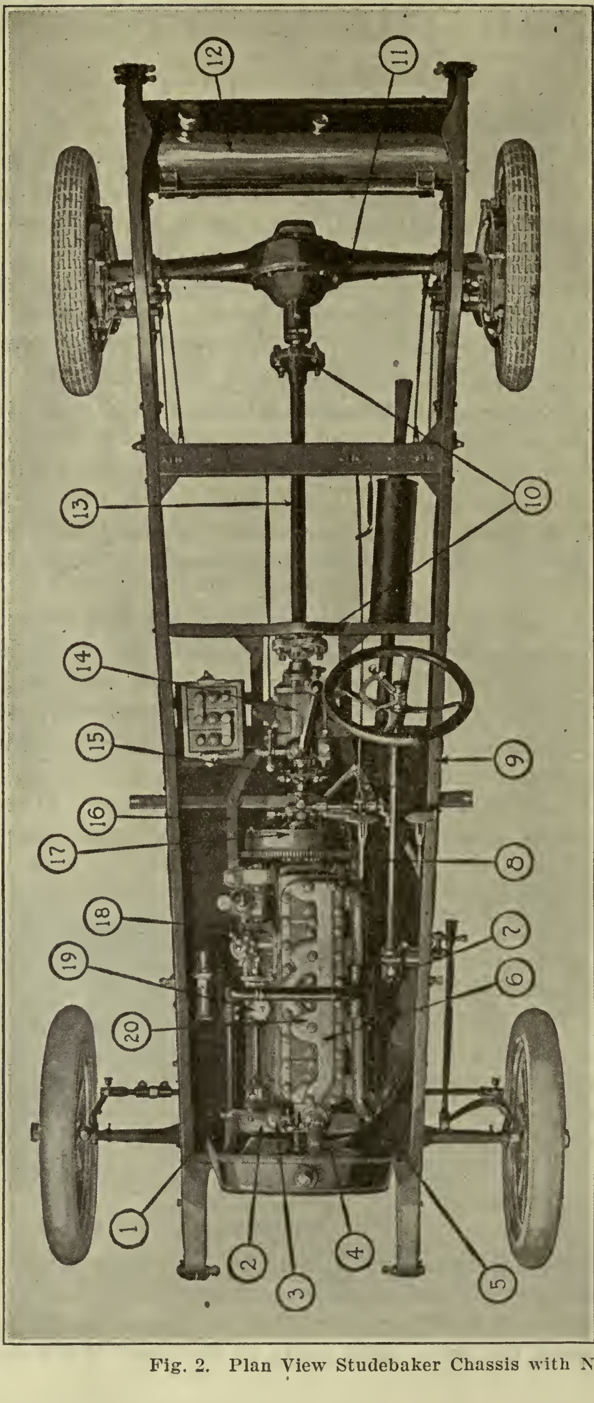


Fig. 1. Cadillac Frame and Springs.

Springs. — The correct method of springing a car is one over which manufacturers and designers have puzzled and labored for years. On the springs depends in large measure the roadability of the car. The springs dare not be neglected if we would secure long life from them or from the more vital parts of the car. They must



1—Silent chain adjusting nut.
2—Aluminum timing gear case.
3—Oil filler pipe.
4—Thermostatic water regulator.
5—Exhaust manifold.
6—Aluminum detachable head.
7—Warm air stove and pipe leading to carburetor.
8—Starter motor and bendix drive.
9—Deep channel section straight side frame.
10—Flexible disc universal joints, requiring no lubrication.
11—Pressed steel rear axle housing.
12—15-gallon gasoline tank.
13—Tubular propeller shaft.
14—Transmission suspended at three points on sub-frame.
15—Flexible disc coupling between clutch and transmission.
16—Sub-frame carrying motor clutch and transmission.
17—Flywheel containing single dry plate disc clutch.
18—Accessory unit containing generator, water pump, oil pump, distributor, coil and relay.
19—Horizontal feed carburetor.
20—Horizontal intake manifold, water manifold and detachable head.

Fig. 2. Plan View Studebaker Chassis with Names of Parts.

take all manner of twists, strains, jars and jolts, besides carrying the weight of the car and load.

Through the front springs must be transmitted the steering effort. That is, when the wheels are turned there is a tendency for the car to continue in its course while the wheels and axle tend to leave their rightful position under the car. The springs while relieving the car of the road shock, must also exert a side strain or pressure to carry the car out of its forward course to the side and around the corner. These things it must do and not permit the steering gear links to become disarranged so that faulty steering or accidents result.

The front springs also keep the front axle in alignment. If one is broken, the axle may drop back and cause an accident or at least a hard steering car.

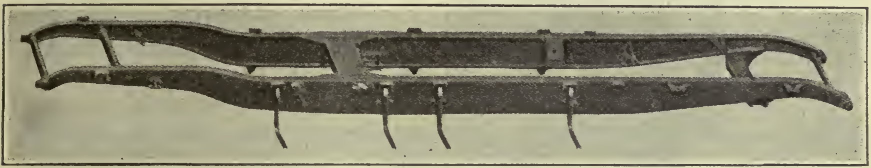


Fig. 1-A. Cadillac Motor Car Frame.

To prevent breakage the following points must be observed:

Keep the shackles lubricated and snug.
Keep the spring clips tight.
Keep the center bolt tight.
Keep the leaves well graphited.

What has been said of the front spring applies to the rear spring as well. Here we have in many cases additional strains and stresses due to a greater load and the fact that the driving effort is transmitted from the axle to the frame of the car through the springs.

Radius Rods.—Radius rods are not found on all chassis. They may be used on the front or on the rear to hold the axle in line with the frame and the other units of the car while permitting the proper spring action.

Hotchkiss Drive.—This is the name applied to the type of spring suspension and rear axle drive where the rear axle is carried by semi-elliptic springs. No radius rods, torque tubes or torque rods are supplied. Instead the axle is clipped to the springs in rigid position, no turning at the spring seat being permitted. This throws the torque as well as the driving effort and car load all upon the springs. In cases where the rear axle is supplied with a torque tube or rod to keep the axle from turning, under driving strains, the spring seats are arranged with a bearing permitting a certain amount of oscillating movement.

Quarter Elliptic Springs.—This type of spring is in use on some of the lighter cars for both front and rear axle work. The spring is used inverted and the heavy end is clipped rigidly to the frame of the car. This type is also called the cantilever.

Fig. 3. Essex Chassis.

Semi-Elliptic.—More of this type are used than any one other. It is used almost altogether on the front, and in a very large number of cases on the rear. Its peculiar advantage seems to be in the fact that it permits lively spring action within a reasonable range. This results in safer steering and less rear axle trouble.

Three - Quarter - Elliptic.—Formerly quite popular, this spring has been largely superceded by the semi-elliptic and cantilever for rear end work. Where used, the drive is in most cases through the lower semi-elliptic and the added quarter is attached to the frame of the car and projects rearward to meet the lower half.

Full Elliptic.—Used in a few cars this spring is noted for its ease of riding. In the case of the Franklin car the drive as well as the steering effort is regulated and controlled by or through the springs. This necessitates very careful and rigid mounting of the upper half since no radius rods are used. In cases other than the Franklin, radius rods are in use thus permitting of different types of spring mountings.

Cantilever.—For use on the rear end of motor cars the cantilever spring is favored by a number of manufacturers. The spring is shackled at the front end, the center is pivoted, and the

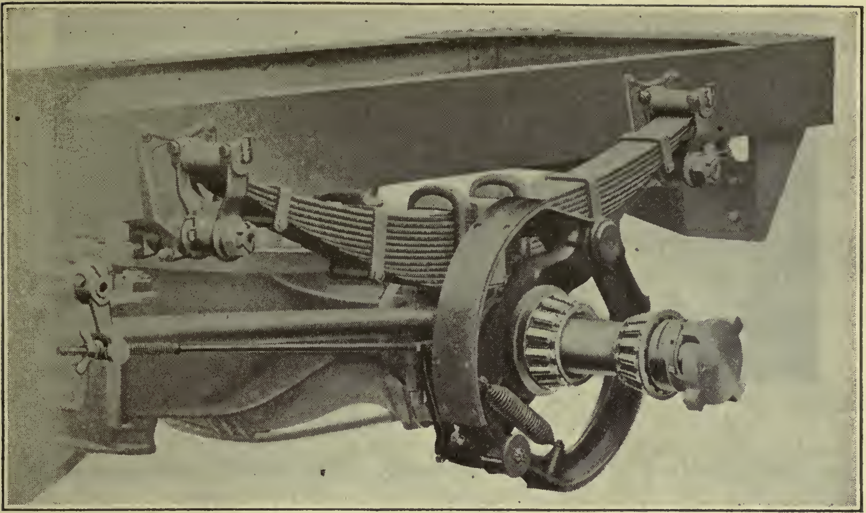


Fig. 4. Rear of Packard Truck Chassis, showing frame and spring suspension. Note also Radius Rod.

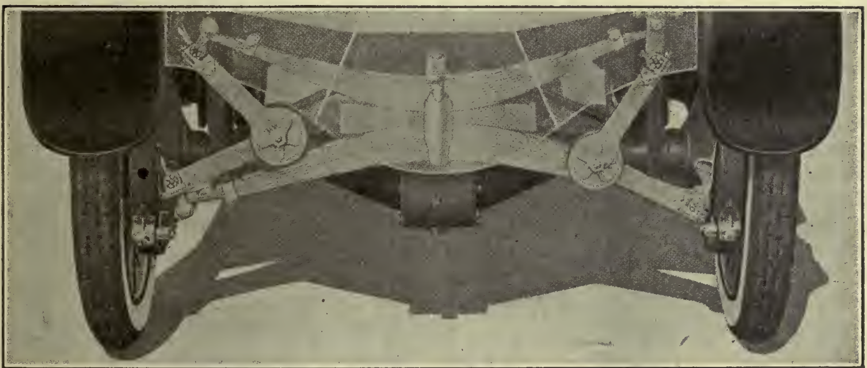


Fig. 5. Marmon Springs.

Fig. 6. Buick Hydraulic Pressed Steel Frame.

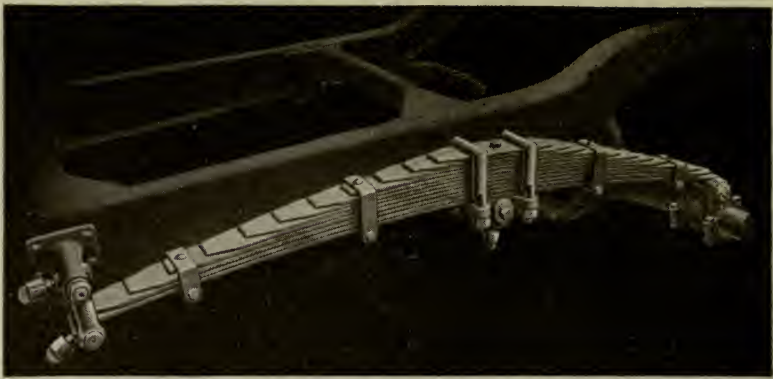


Fig. 6A. Buick Cantilever Spring.

rear end attached to the axle housing. The spring affords a large measure of riding comfort, due to its ability to absorb road shock without transmitting the same to the car body and passengers.

JOB 1. TIGHTENING SPRING CLIPS.

Fig. 7 shows the proper method of tightening the spring clips. It is not advisable to draw up on one of the nuts to the neglect of the others, but draw on each in turn, so that the same tension is put on each. Owing to the fact that the clips and nuts and threaded portion of the clips are exposed to all manner of dirt, and are very frequently wet and mud coated, it is to be expected that they will rust. They should be tightened each month or every 2,000 miles. Keeping these clips tight is the only known spring insurance. Proceed as follows to tighten:

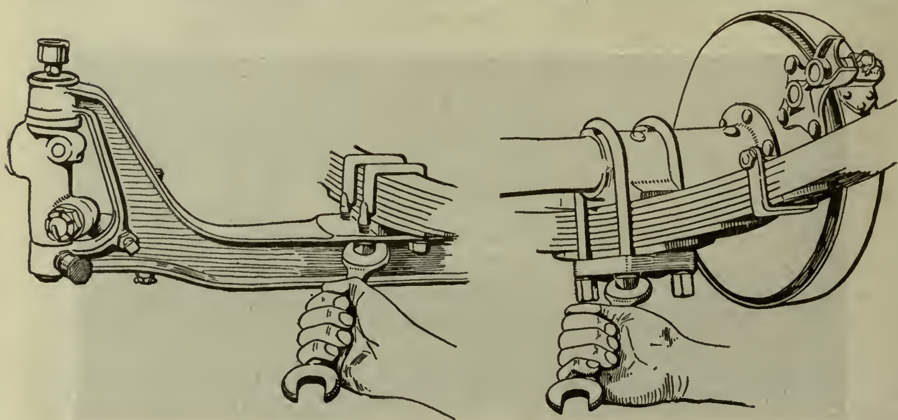


Fig. 7. Tightening Spring Clips.

1. Select an end or socket wrench which is a snug fit on the clip nuts. Use a creeper to roll under the car. Take an oil can with you.

2. Test the nuts to see if they are rusted. If they show signs of sticking turn them off rather than on. Use oil to help loosen them and to prevent further rust. When all four nuts of any one set of clips are working freely they should be drawn up snug and tight.

3. If the car is new there is little likelihood of rust, and the clips may be drawn tight at once.

4. Where a rusted clip nut is tightened before it is freed on the clip end, it is very misleading, as the workman thinks he has the job snug when the clip is still quite loose.

5. Where the small center bolt shows, this should always be tested to see that the nut sets snug.

JOB 2. ADJUSTING SHACKLE BOLTS.

One of the most annoying rattles about a car is caused by the side play in the spring ends in the shackles.

In some cases this can be overcome by drawing up on the shackles and in other cases it is necessary to add shims.

TIGHTENING BY USE OF SHIMS. FIG. 8.

1. First crowd the spring to one side of the shackle using a heavy screw driver to pry with.

2. Measure the thickness of the shim required. This may be sheet brass or sheet steel.

3. Remove the shackle bolt and clean it of all grease and dirt. Make certain that the oil or grease grooves are clean.

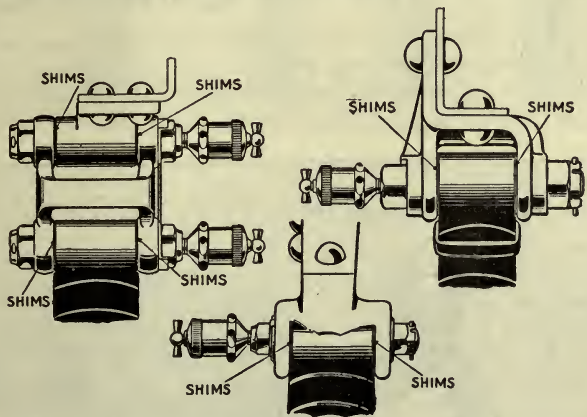


Fig. 8. Adjusting Shackle Bolts by the Use of Shims.

4. With a rag and kerosene, clean the eye in the end of the main spring leaf.

5. Cut the shims to the shape of a washer, having drilled or punched the hole first. If this is not done the shim is very hard to hold.

6. Put some engine oil in the eye and on the bolt and reassemble with the shim in place. The shim may be tight enough to require some crowding to get it in place.

7. Draw up on the nut until it is just fairly snug. Insert a cotter key.

8. After the car has been in service a short while the shackles should be inspected and tightened again.

TIGHTENING BY DRAWING ON NUTS. FIG. 9.

1. Proceed to remove and clean as above.

2. Replace, turning the bolt into the threaded shackle until no play is evident. If too tight, a very bad condition is present. The shackle holds the spring eye as in a vise and the result may be a broken spring at a short distance from the spring eye. It is likely also to give forth a harsh grating noise as the parts work together.

3. Replace the nut and cotter key.

4. In some cases the shackle side is not threaded. In adjusting this type it is only necessary to draw up on the nut and replace the cotter key.

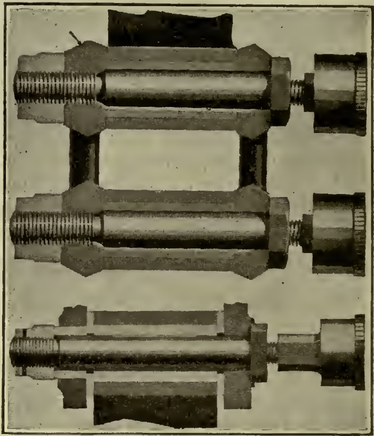


Fig. 9. Adjusting Shackle Bolts.

JOB 3. LUBRICATING SPRING SHACKLES.

Due to the constant action and the weight carried as well as the liability of foreign matter to work into them the spring shackles are in constant need of attention.

The usual plan of lubrication is to drill a hole through the center of the bolt and then another one in to meet this midway between the two ends. A flat portion is also provided at this point to permit the grease or oil to work out into the spring eye.

1. Where grease cups are used they should have one turn daily when the car is in service. Use a medium cup grease.

2. Where oilers are used they should be kept full, or receive an application daily.

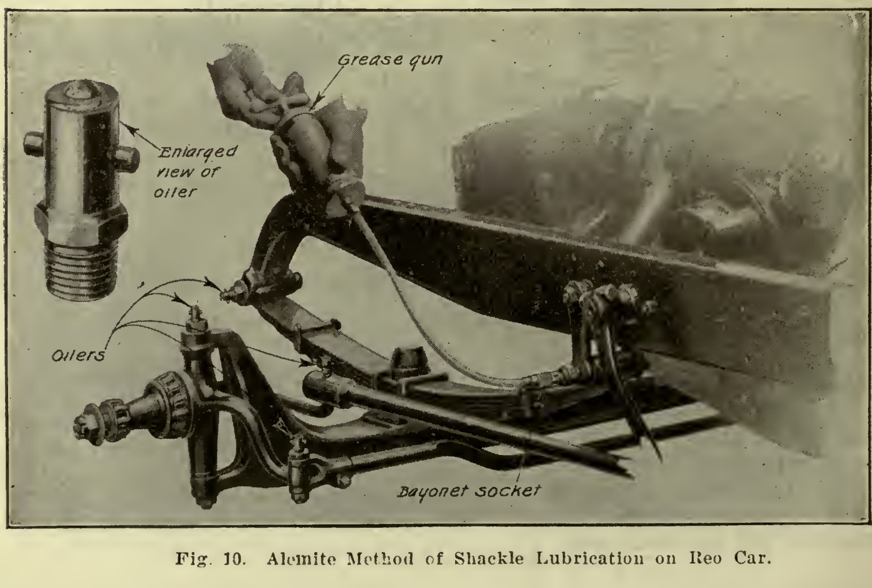


Fig. 10. Alemite Method of Shackle Lubrication on Reo Car.

3. The trouble with all shackle lubrication is the liability of the oil or grease ducts stopping up.

4. To open up the oil holes or ducts remove the bolt and clean as suggested in Job 2.

5. Fig. 10 shows a special oiler and grease gun used to lubricate the Reo car shackles. The bayonet socket is slipped over the bayonet end of the oiler. Grease may then be forced from the grease gun into the shackle.

6. At least once each season, preferably in the spring after the weather conditions are settled and less mud will be encountered, the shackles should be taken apart and cleaned thoroughly.

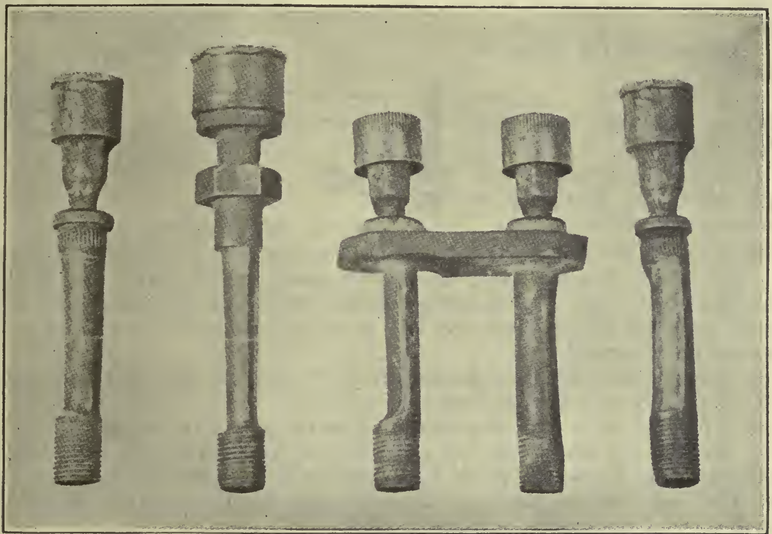


Fig. 11. Shackle Bolts Worn for Lack of Lubrication.

JOB 4. GRAPHITING SPRING LEAVES.

When the leaf springs are assembled in the factory they are properly lubricated by giving each leaf a coat of oil or grease over its entire surface. This grease is worked out in service and requires frequent replacement. Several preparations are on the market which will penetrate through between the spring leaves if they are applied to the side of the spring. If the spring is not too dry a good grade of oil will do the same. The standard practice in spring lubrication as followed in the garages is as follows:

1. Set the jack under the frame of the car and remove the weight from the spring.

2. Use some device to spread the leaves, having first removed the small spring clip bolt, if that is possible. An old screw driver or spring leaf end may be driven between the leaves to spread them, or a special spring spreader such as is shown in the illustration, Fig. 12, may be used.

3. The best grease to use for spring lubrication is powdered or flake graphite mixed with engine oil, or some of the finer grades of graphite grease.

4. Use an old hack saw blade or thin strip of sheet metal to insert the lubricant between the leaves.

5. Continue the work until all parts, which it is possible to separate, have

been lubricated. The grease will work from these points to those points which it was impossible to separate far enough to insert the saw blade.

JOB 5. SPRING OVERHAUL.

Where the springs are badly rusted or where there is a broken leaf to be replaced it is necessary to remove the spring from the car.

1. Jack up the car, having the jack placed under the frame.
2. Block the car frame in this position.
3. Remove the shackle bolts, as well as the axle spring clips.
4. Take the spring to the bench where the first step is to remove the center bolt.

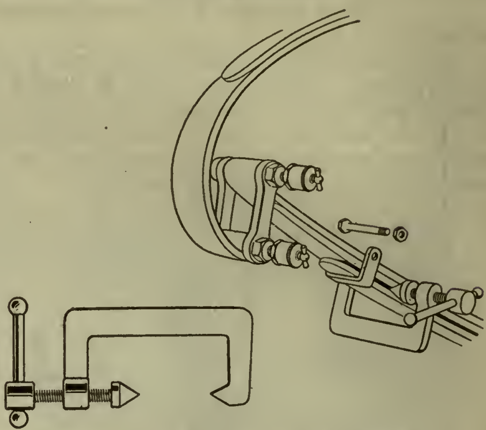


Fig. 12. Spreading Spring Leaves.

5. Remove the shorter leaves, laying them aside. To remove or separate the longer leaves, it is necessary to open the small spring clips. This is simple in the case of the type shown in Fig. 12, but where the one piece type is used a chisel must be driven under the end to raise them sufficiently to allow the leaves to be separated.
6. Use a coarse grade of sandpaper to remove all rust, dirt and scale.
7. Refit any new leaves needed.
8. Apply an even coat of graphite lubricant to the spring surfaces.
9. Reassemble the spring, being certain to have all the long ends together. Springs are very frequently made with the bolt hole closer to one end than the other. In cases where this is considerable it is easily detected, but in slight cases it is often the source of much trouble.
10. When all the leaves are laid together use a "C" clamp, or a vise to hold them until the center bolt is in place.
11. Next see that all clamps are properly tightened: To tighten the single piece type a few blows from a hammer are sufficient.
12. Replace under the car making certain that the spring is not inserted backward. Where the center bolt is offset the short end, if a front spring, goes to the front, if a rear spring, the short end goes to the rear in most cases. This is done to give a longer wheel base.
13. All shackles should be cleaned and properly adjusted.

JOB 6. STRAIGHTENING A WRECKED OR BENT CAR FRAME.

It very frequently happens that in a wreck certain parts of the frame are sprung, bent, or broken. If the trouble is merely a bent portion the repairman may proceed with confidence to put it back in proper condition.

1. Remove those portions of the car mounted close to the damaged part. This may mean that only the fender and skirts close to the damaged section need be removed, or it may mean every unit mounted on the frame must be removed. If the frame is sprung out of line either vertically or horizontally, it will be necessary to strip the frame to permit of lining it with a center wire.
2. With the damaged part exposed and accessible, the next step is to secure the proper equipment to handle the work. It is far better to use a bending bar, or jacks, to exert the pressure than to use a sledge to drive with.

3. Apply heat from a welding flame, gasoline torch, or kerosene pre-heating torch to the portion of the frame which it is desired to straighten. By localizing the heat to the damaged spot it is quite possible to bring the portion back to the original position with the least effort, and without putting some other part out of line.

4. Keep a fire extinguisher at hand in case of need.

5. In case the entire frame is out of line it is possible to chain the ends to a heavy timber, set a screw jack at the sprung portion and thus exert pressure at the correct point to spring it back into position.

5. When the frame has been brought into approximate position, the smaller bends, kinks and irregularities may be removed by heating and hammering. A heavy sledge to back up the blows is indispensable for this work.

CHAPTER 2

STEERING GEARS AND FRONT AXLES

The five most common types of steering gears are the screw and nut, the worm and sector, the worm and gear, the planetary gear, and the pinion and sector.

Any type may be said to be irreversible which has sufficient gear reduction, so arranged that there is little or no chance of the road shock being transmitted to the wheel. That is, power or effort can be transmitted only from the hand wheel to the road wheel and not in the reverse direction. This insures greater safety and comfort to the driver.

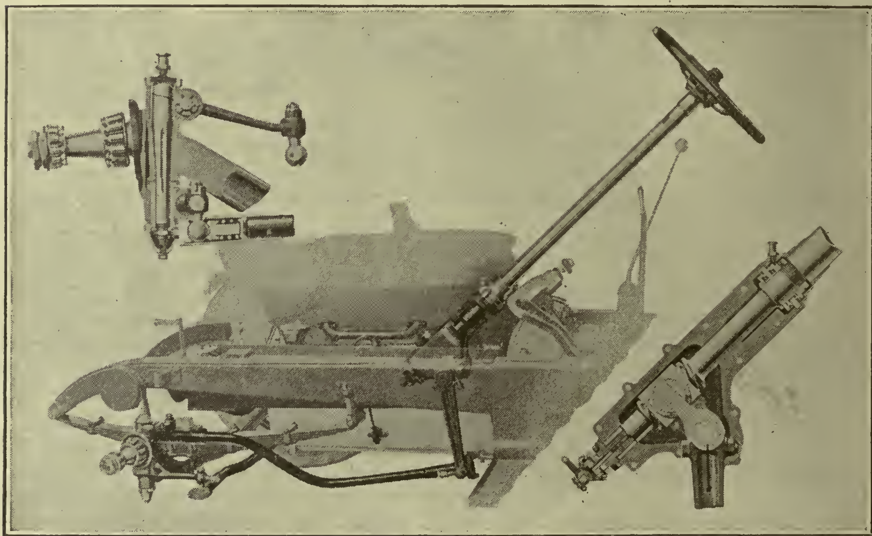


Fig. 13. Packard Twin Six Steering Gear, Linkage and Front Axle.

Planetary Steering Gear.—The planetary type, as arranged on the Ford steering gear, is shown in Fig. 29. The brass internal gear is held rigid by the steering gear post. The pinion gear on the steel shaft attached to the hand wheel is rotated with it. The planetary gears are thus given two motions. First they are caused to rotate on their central pivots, but they cannot rotate on their pivots without causing the spider on which they are mounted to rotate. While rotating each planetary gear moves forward or backward in a circle around the central gear within the outer gear. From the spider shaft the steering effort is transmitted to the steering arm and then through the drag link to the steering knuckles and wheels. This is somewhat the same principle as used in the Ford transmission for gear reduction. The gear reduction is approximately 4 to 1.

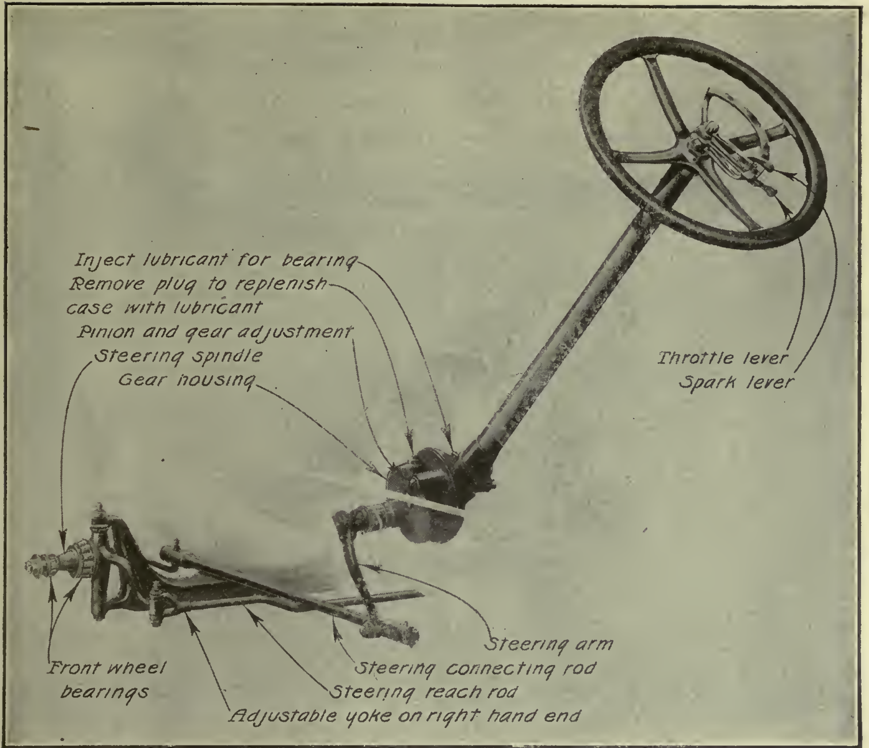


Fig. 14. Reo Steering Gear and Linkage.

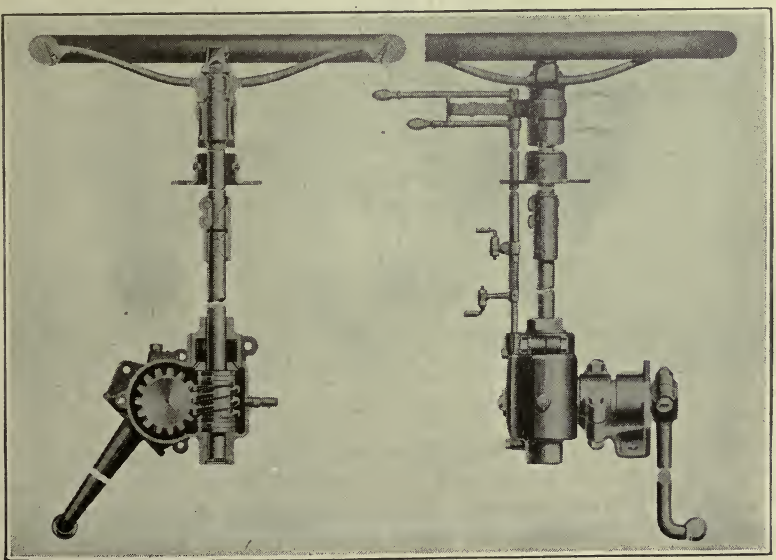


Fig. 15. Dodge Steering Gear.

Worm and Gear.—The worm and gear secures its name from its type of construction. A worm is fastened onto the lower end of the shaft having the hand wheel attached to the upper end. Turning the worm causes the gear shaft in mesh with it to be rotated or

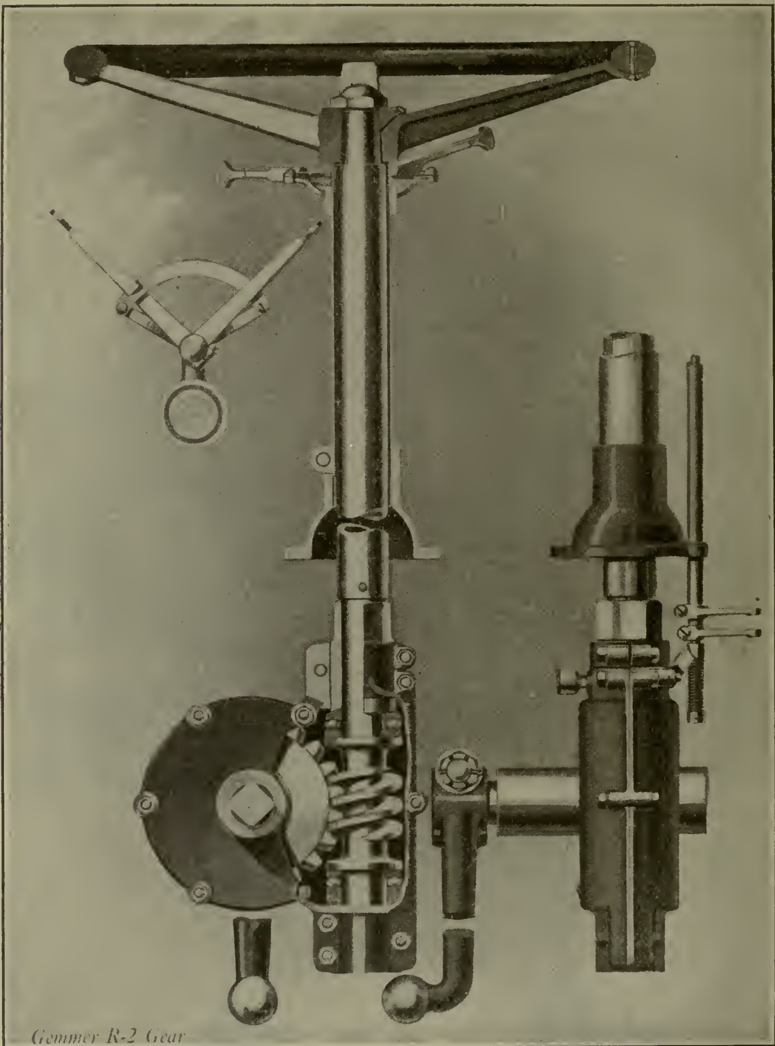


Fig. 16. Gemmer Worm and Gear Steering Gear.

oscillated. This gear shaft in turn carries the steering gear arm. An attempt to turn the worm and hand wheel by turning the steering gear arm will show exactly how irreversible the transmission of power may be. Turning the hand wheel gives an idea of the power developed.

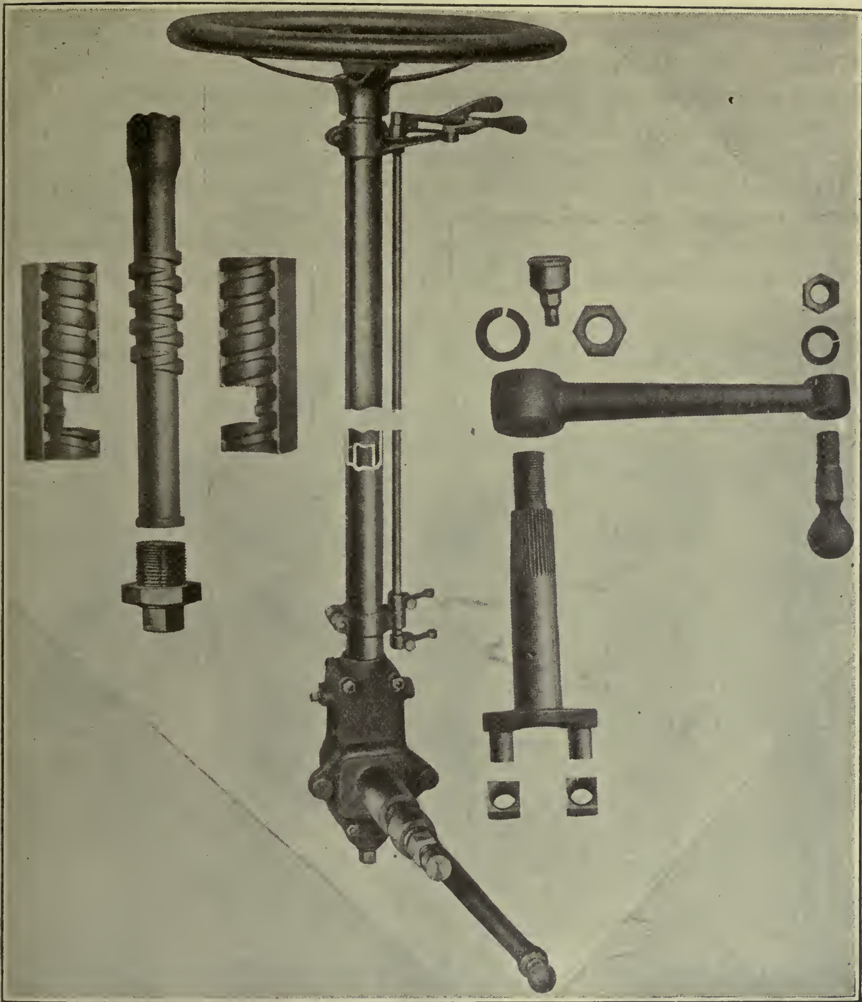


Fig. 17. Lavine Screw and Nut Gear, Details and Assembly.

The gear ratio varies from about 7 to 1 in touring cars to about 11 to 1 in the case of heavier cars and trucks, according to the duty imposed on it.

Worm and Sector.—This is approximately the same as the worm and gear with the exception that since only a sector of gear is used it cannot be adjusted for wear as can the worm and full gear, where a new quarter may be turned to come in contact with the worm, thus compensating for the gear teeth which may have been worn thin.

The Screw and Nut.—The screw and nut type is compact and efficient. Instead of the worm a screw thread is used. The thr

on the screw is cut both right and left hand. One side, or half of the head or nut, is cut with left-hand threads, and the other side of the nut or head is cut with right-hand threads as shown in Fig. 17. Consequently, as one-half of the nut is going up on the thread, the other side is going down, and vice versa. The half nuts or heads are so arranged as to actuate rollers or trunnion blocks, which in turn actuate the shaft and steering gear arm. This type is termed the semi-irreversible as it will permit the front wheels to follow the sand or mud ruts without any care from the driver. On the other hand

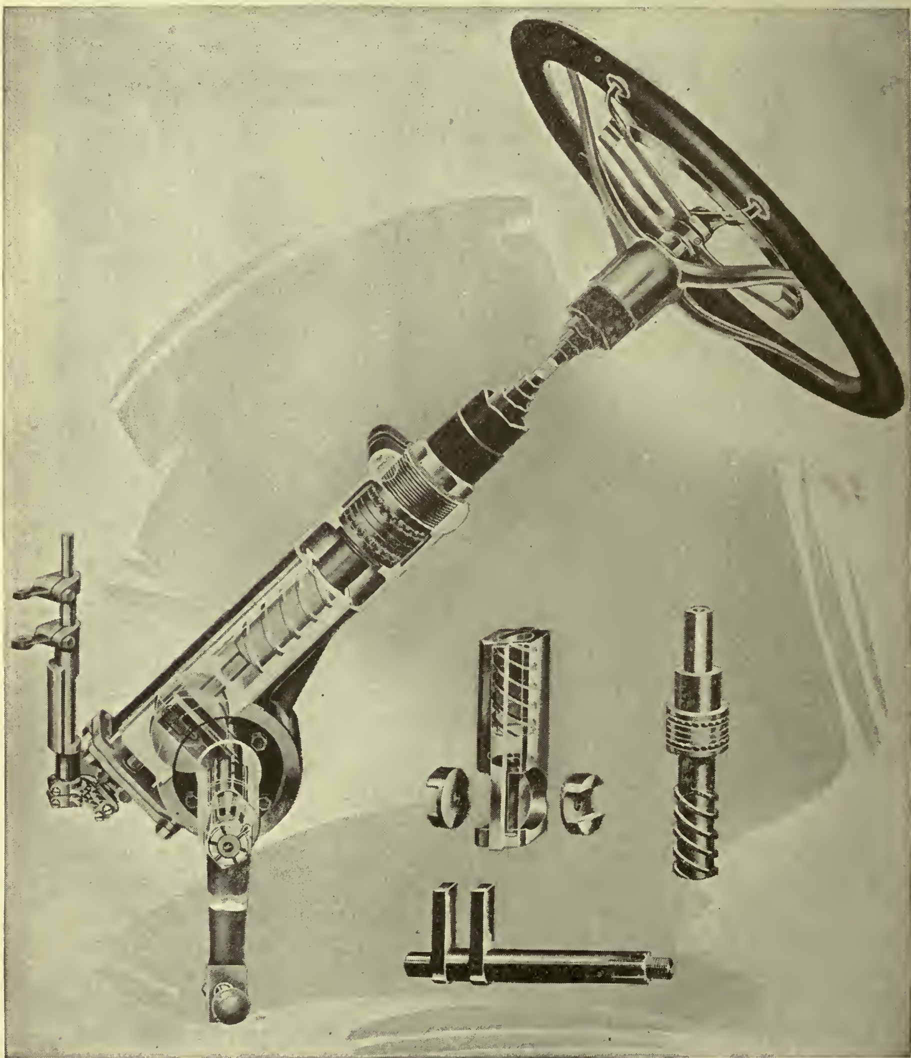


Fig. 18. Ross Fore and Aft Steering Gear for Trucks.

not enough road shock is transmitted to the wheel to cause undue tiring of the driver.

Pinion and Sector.—Here the worm and screw thread is replaced by a pinion. The pinion actuates a section of gear similar to a ring or bevel gear. The pinion and sector are exposed, not being encased in the housing as in all other types. The action is very direct and road shock is transmitted rather forcefully to the hand wheel. This type is obsolete.

FRONT AXLES

Front Axle Types.—The types of front axles most popular today are the Elliot, Reversed Elliot, and Lemoin. In a few cases tubular

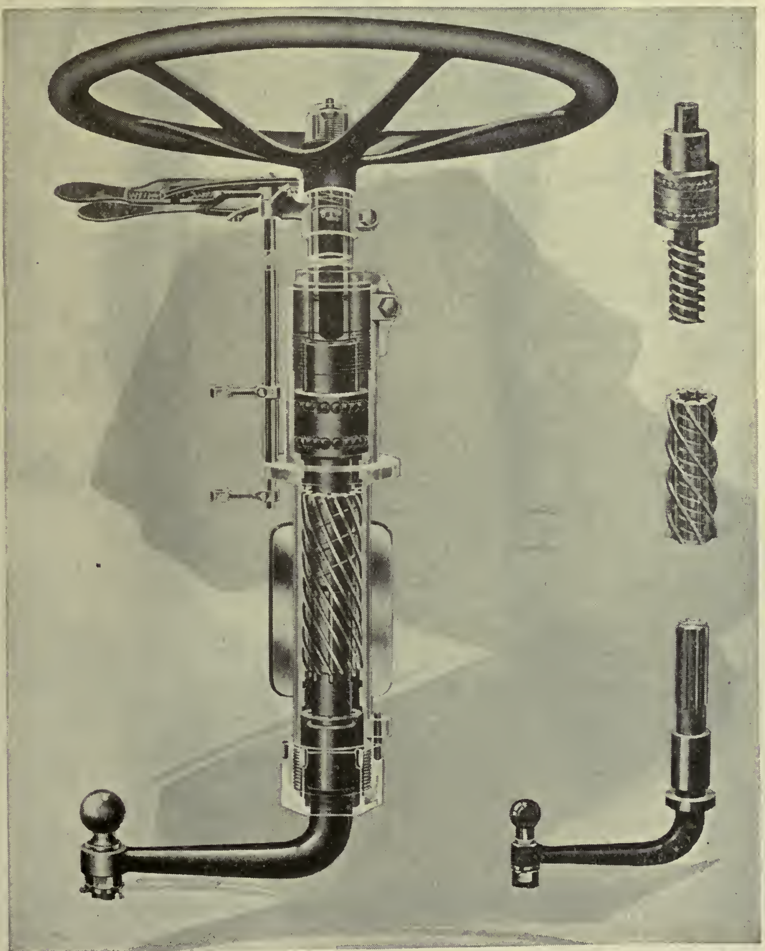


Fig. 19. Ross Cross Steering Gear for Trucks.

axles are still used though this is comparatively seldom. The usual type or style of section of the axle resembles the "I" beam. Lightness and strength, together with great ability to resist crystallization and consequent cracking and breaking, are prime essentials. A

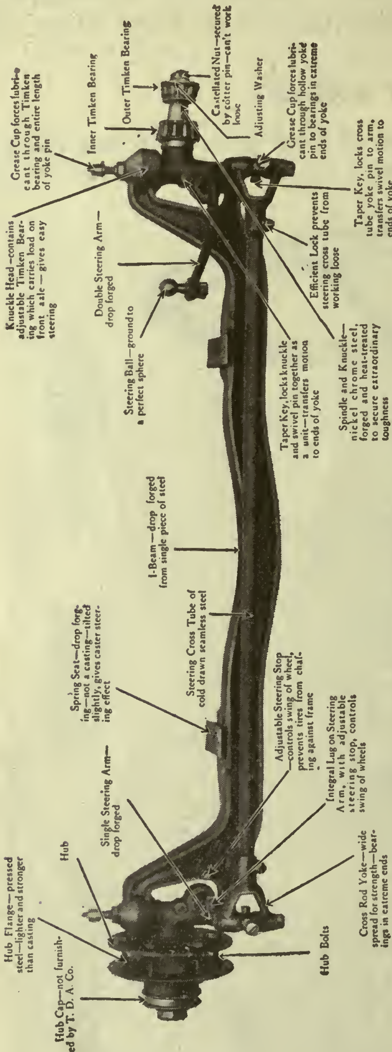


Fig. 20. Timken Detroit Front Axle of the Elliot Type, I Beam construction.

Fig. 21. Timken Detroit Commercial Car Front Axle. Note heavy, substantial construction.

good piece of axle steel will stand considerable bending and straightening while cold without breaking.

Axle Repair Work.—The usual types of repair jobs on the front

axle include, rebushing of yokes, replacing of "King Bolts" or steering knuckle pivots, aligning front wheels, adjusting front wheel bearings, straightening sprung axles, replacing or straightening front radius rods, and work of like nature.

Front Axle Design.—In the case of the front axle as elsewhere the student must understand the principles incorporated in the design

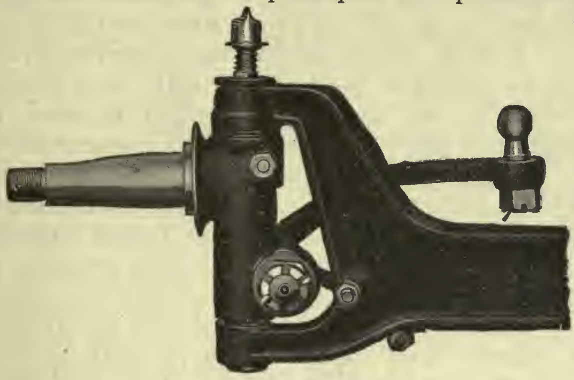


Fig. 22. Axle End showing Spindle and Steering Arm.

of the axle if he is to make repairs on it, otherwise he may do that which would leave the car unsafe to be operated on the highways in some cases, and in other cases be the source of continuous expense to the owner. In designing the front axle three important items are cared for. These are camber, toe-in, and castering effect. The repairman must be able to retain these in making repairs in the same proportion in which they were originally provided.

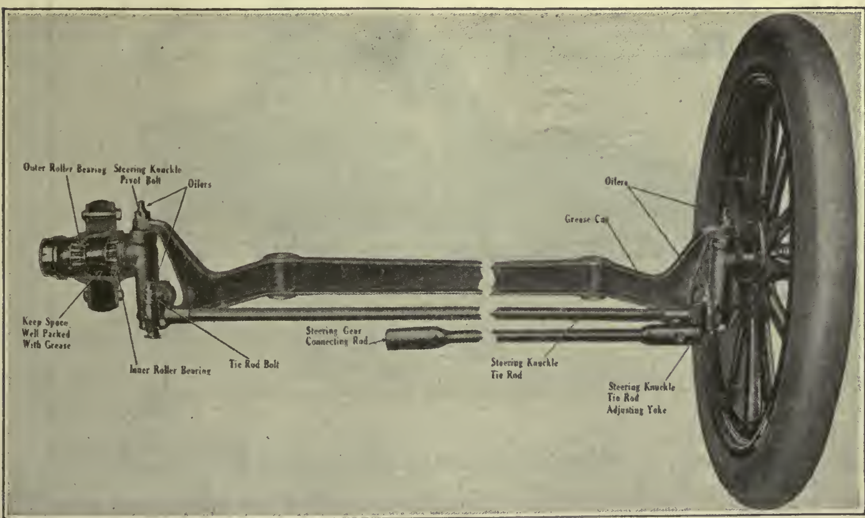


Fig. 23. Overland Four Front Axle. Note Camber provided.

Camber.—The camber of the front axle is provided for several reasons. First to allow the car to hold the road better, especially when the road is crowned. A second reason is to have the weight of the car and load transmitted in a direct line through the center of the spokes of the front wheel, (which is usually dished) from the hub to the rim, to the tire, to the road. If no camber were provided the wheel would tend to exercise an undue strain on the steering knuckle and spindle. A third reason is that the closer under the steering knuckle pivot the center of the tire is brought as it comes in contact with the road, the less the effort required to steer the car. A correspondingly less degree of road shock is transmitted to the steering wheel. The amount of camber varies from a slight amount to as much as three inches. That is, the center of the tires at the top of the wheels will stand as much as three inches farther apart than the center of the tires at the bottom of the front wheels. The method of providing the camber is indicated in Fig. 23.

Toe-In.—Toe-in, as it is called, is provided by bringing the front of the front wheels closer together than the rear of them. This is done to make the car easier to steer, and to compensate for the tendency of the wheels to flare out at the front when being operated at speed over the road. The amount of the toe-in provided falls within rather definite limits, 3/16″ to 5/16″ being the standard amount allowed. Refer to Fig. 24.

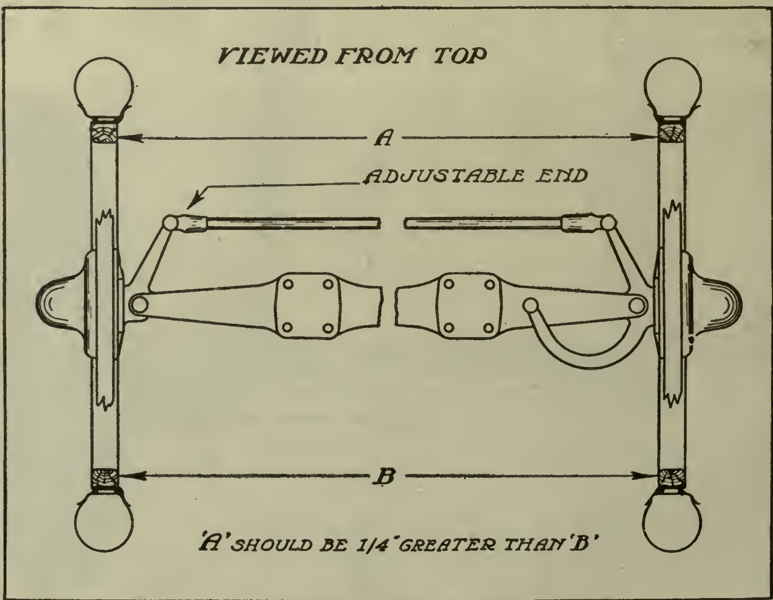


Fig. 24. Illustrating Toe-In.

Castering Effect.—This also is provided that steering may be easier and safer. Instead of allowing the steering knuckle pivot to stand straight up and down, or perpendicular, the lower end is brought forward and the upper end is thrown backward. This is much the same as the pivot is arranged in a bicycle. Fig. 25 shows how the steering axis is thus brought ahead of the point of actual contact with the ground. This construction is the feature that permits the rider of the bicycle to ride and steer the wheel without touching the handle bars. The same principle is in use in the casters on which a piece of furniture rolls over the floor. The casters always align themselves with the direction in which the piece is being moved. The castering feature as applied to automobiles will cause the front wheels to align themselves with the direction of travel of the car. After rounding a curve, the wheels automatically attempt to straighten out and keep straight with the car and road.

Fig. 25. The steering axis meets the ground in advance of the point of contact of the wheel.

Steering Knuckle Arm Design.—Still another feature of front axle design is the shape and position of the steering knuckle arms. Generally speaking, if lines were drawn through the centers of steering knuckle pivots and tie rod bolts they would meet close to the center of the rear axle. This may be noted in Fig. 2. This provides the proper mechanical movement and length of the lever arm to cause the front wheels to be held in a perpendicular position with

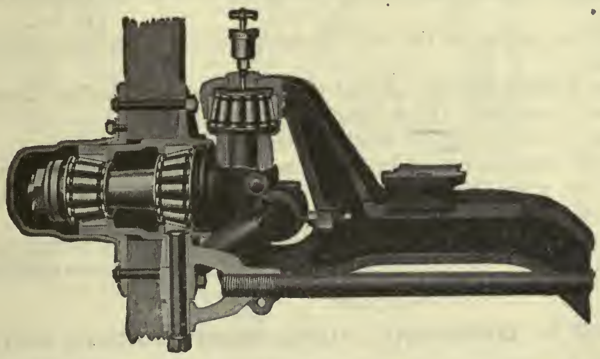


Fig. 26. Application of Timken Roller Bearings to the Spindle and to the Knuckle Head.

reference to whatever radius they may be traveling on in rounding a corner.

Since the front axle of the car is fixed, the front wheel on the side toward which the turn is made will always be ahead of the other one with reference to the center of the curve being rounded. As a consequence of this the same radius would not strike the center of each

wheel, and since the wheels must be maintained perpendicular to the radius the car is traveling on the wheels, they would not be parallel on a curve as they would be on a straightaway. A test made on cars in the shop will prove this. In attempting to verify the above, first turn the wheels of the car to the side sharply. If lines are next stretched along the sides of the front wheels it will be found that they will meet at a distance ahead of the car depending on the amount the wheels are turned aside and on the length of the wheel-base of the car.

These matters are not presented with the idea of confusing the student, but rather that he may have such an understanding of the principles of design that an axle to be repaired in any detail may be so cared for as to insure safety and service without undue wear and strain being placed on tires, knuckles, spindles, bearings, bushings, steering gears, and other details affected.

JOB 7. TESTING AND RE-ALIGNING FRONT WHEELS.

Service and safety are absolutely dependent on proper alignment of the front wheels.

1. Jack up both front wheels.
2. Turn them, noting whether they run true.
3. Resting a soft pencil on a block or box mark the center of each tire as the wheel turns.
4. Set the wheels in true with the car. (Straight ahead.)
5. Measure from center to center, or from mark to mark on the exact front of the wheels. Use a strip of wood, marking the distance with a pencil. A better device is the adjustable measuring device illustrated in Fig. 27. This insures the same distance from the floor being used at the front and rear of the wheel.
6. Test the marks on the rear of the tires. Is there any difference in the measurement?
7. How much difference should there be, and why is this allowed?
8. What is camber? How much is allowed?
9. What is toe-in? How much should be allowed?
10. If the amount of toe-in is not correct, the clamping screw in the adjustable tie rod yoke should be loosened. Remove the yoke pin and turn the yoke on or off as desired.
11. After the adjustment is again tested and found to be correct, the yoke pin and the locking or clamping screw are replaced and tightened. Make certain that the cotter keys are in place.

JOB 8. OVERHAUL FORD FRONT RADIUS ROD.

A common fault of the Ford car is to have the front radius rod sprung by striking a rut or curb.

1. Remove the lower half of the ball joint bearing which is the ball joint cap. Place parts where they will be kept safely.
2. Remove cotter keys from front ends of radius rods.
3. Loosen nuts until just even with ends of radius rod.
4. With a lead or bronze mallet jar the ends loose from the axle. If no soft metal hammer is at hand use a wood mallet, or a piece of hard wood under a hammer.

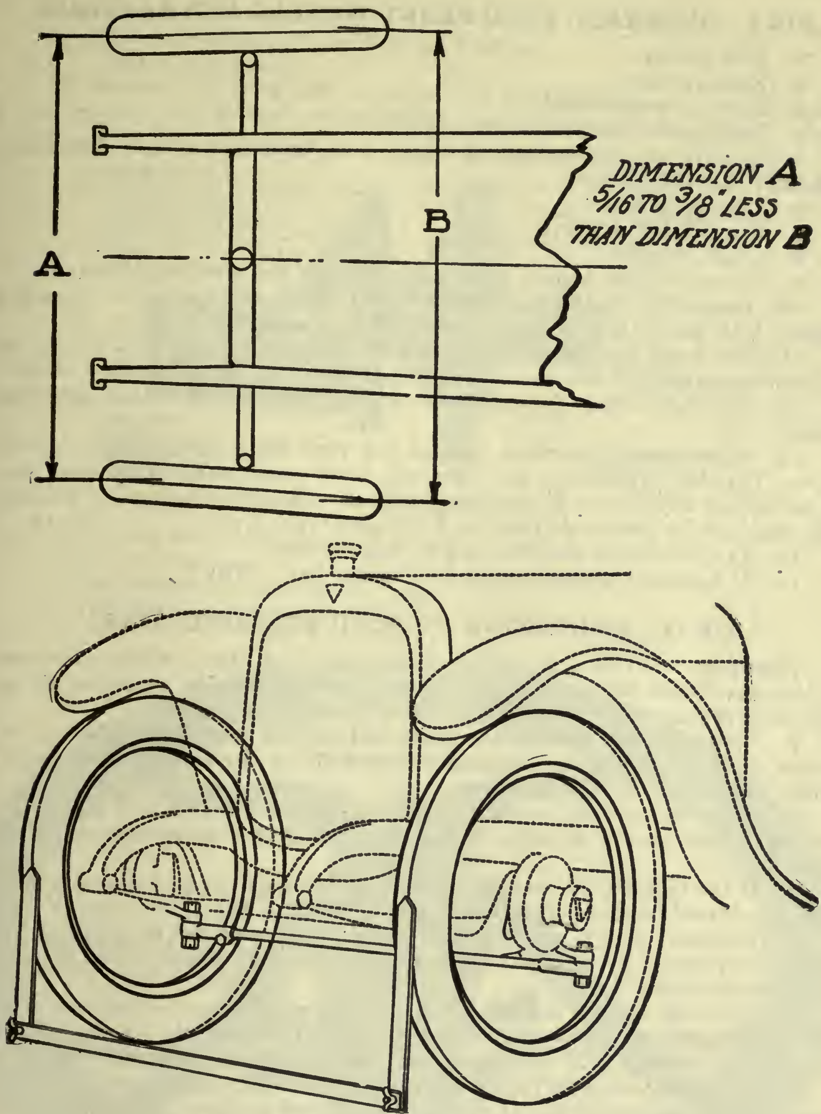


Fig. 27. Testing the Alignment of Front Wheels.

5. Remove nuts. Place away.
6. Remove radius rod and clean.
7. Test rod for alignment and any bends.
8. If out of true, get instruction for straightening on arbor press.
9. In straightening Ford parts of this nature no heat is applied, they are straightened cold.
10. Have work inspected and if approved reassemble in the car. Do not reverse in axle or it will throw the front axle out of plumb.
11. Inspect to see if all is tight and all cotters in.

JOB 9. OVERHAUL FORD FRONT WHEELS AND BEARINGS.

1. Jack up car.
2. Remove hubs.
3. Remove cotter keys.
4. Remove castellated nut and washer.
5. Remove adjustable bearing cone. One spindle has right and other left-hand threads. Why?
6. Remove wheel.
7. Remove felt washers.
8. Clean all parts.
9. To remove and inspect balls first compress and remove ball retainer.
10. Inspect all steel balls for cracks and pits. Remove defective ones and replace with good. If very bad, all should be replaced.
11. The inner bearing cups may be pressed or drifted out if their removal is found necessary. They are a press fit and should be replaced when worn.
12. All parts being cleaned they may be reassembled. Pack with cup grease.
13. After wheel is in place, test for side play due to too loose an adjustment. Test for tightness as too tight will cause undue wear. One good way to get proper adjustment is to tighten until the wheel shows signs of binding, then back off the adjustable cone until the wheel runs freely.
14. Put on washer and nut, and have inspected.
15. If approved, place in cotter key; a new key. Why?

JOB 10. TIGHTENING UP FORD STEERING GEAR.

Should the steering gear become loose, that is, so that a slight movement of the wheel does not produce immediate results it may be tightened in the following manner:

1. Disconnect the two halves of the ball sockets which surround the ball arm at the lower end of the steering post and file off the surface until they fit snugly around the ball.
2. If the ball is badly worn it is best to replace it with a new one. Also tighten the ball caps at the other end of the steering gear connecting rod in the same manner.
3. If the bolts in the steering spindle arms appear to be loose, the brass bushings should be replaced with new ones. Refer to Fig. 28.
4. Excessive play in the front axle parts may be detected by grasping one of the front wheels by the spokes and working it in such manner as to show up any excessive wear.
5. After the car has been in service two or three years excessive play in the steering gear may make necessary the renewal of the little pinions, as well as the brass internal gear just underneath the steering wheel spider.
6. It is also advisable to inspect the front hangers occasionally to overcome any excess vibration. If found, remove old hangers and replace with new ones.

JOB 11. OVERHAULING AND REBUSHING FORD FRONT AXLE.

Refer to Fig. 28.

1. Remove wheels.
2. Remove radius rod.
3. Remove steering knuckle spindles by removing nut and spindle or king bolt.
4. Press out spindle body bushing.

5. Press in new ones.
6. Press out spindle connecting rod bushing.
7. Press in new ones.
8. Reassemble, using care to see that all parts fit properly. In this work it may be necessary to ream the bushings to fit them to the bolts. Any burrs may be removed from bushings with a scraper, knife or fine file.

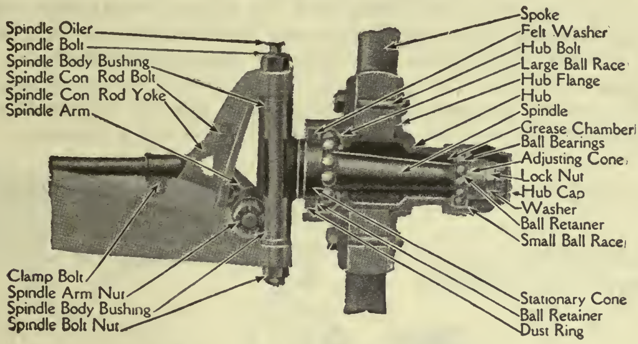


Fig. 28. Ford Front Axle Details.

9. Put on wheels.
10. Test wheels for alignment.
11. Test job for any unfinished work.

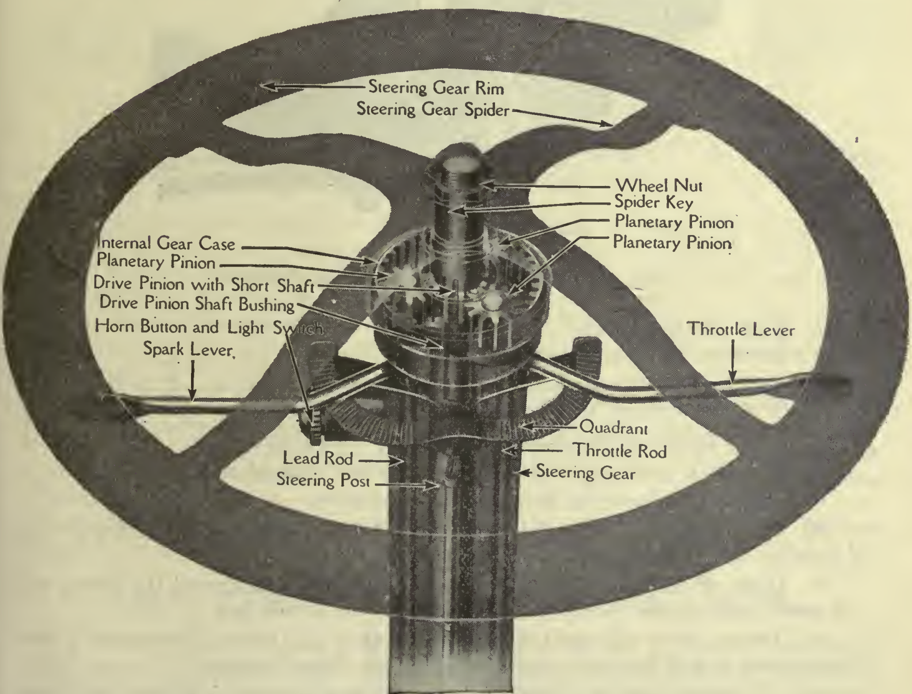


Fig. 29. Ford Steering Gear.

JOB 12. FORD STEERING WHEEL INSPECTION AND LUBRICATION.

1. The steering apparatus is simple and will need little care, except of course proper lubrication.

2. The post gears which are arranged in the "sun and planet" form are located at the top of the post just below the hub of the wheel. Fig. 29.

3. By loosening the set screw and unscrewing the cap, after having removed the steering wheel, they may be readily inspected and replenished with grease.

4. To remove the steering wheel unscrew the nut on top of the post and drive the wheel off the shaft with a block of wood and a hammer.

JOB 13. ADJUSTING AND LUBRICATING TIMKEN FRONT WHEEL BEARINGS.

Due to the line contact design of the Timken bearing the wear is very slow. To adjust proceed as follows: (Fig. 30.)

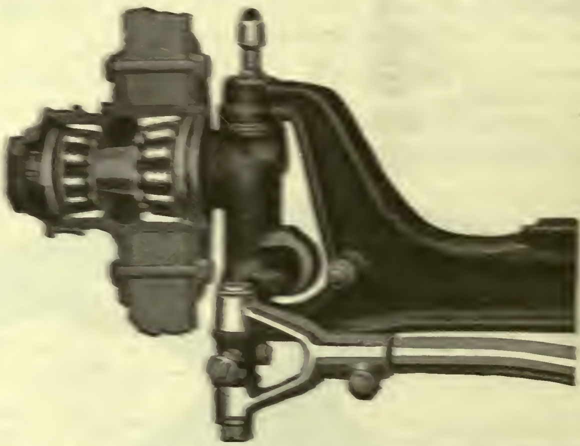


Fig. 30. Adjustable Timken Roller Bearings.

1. Jack up the wheel.

2. Remove hub cap, cotter key and nut.

3. Pull on the wheel, thereby pulling away the bearing. It is sometimes necessary to use a wheel puller.

4. Clean grease from all parts of hub and bearings.

5. Inspect to make certain that all parts are in good condition.

6. Pack in medium cup grease and reassemble.

7. In adjusting the nut it should be turned until the wheel shows signs of turning hard, or of binding on the bearing.

8. Back off the nut slightly, not over one-quarter turn until the wheel will roll easily and evenly on the bearing. Insert the cotter key.

9. The student will want to remember that one front spindle has a left-hand thread and the other a right-hand thread. Why is this?

10. Timken bearings should be cleaned, greased, and adjusted each 2000 miles.

JOB 14. REPLACING FRONT WHEEL SPINDLE CONES OR RACES.

It sometimes is necessary to remove the cone or bearing race which fits over the spindle. This is shown in Fig. 30. These races are worn in normal service but at times a cracked ball or bearing will hasten the wear. When worn or pitted they must be removed and new ones installed.

1. Remove the wheel.
2. With a hammer and drift, work the stationary cone or bearing race off, by driving on the back of it.
3. When replacing use a piece of pipe for a drift as shown in Fig. 31.
4. Do not permit the pipe to rest on the shell which is the roller retainer, or it will be broken. In the case of the inner stationary cone as used on the Ford and other ball-bearing types, the same device is useful as it insures an even pressure and a workmanlike job.

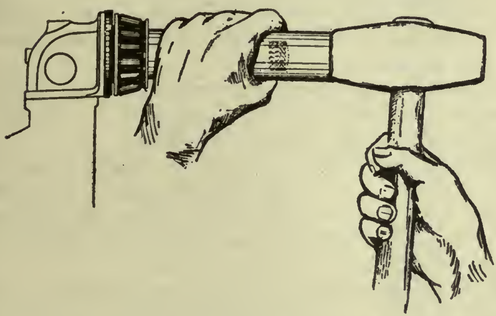


Fig. 31. Mounting Wheel Bearing.

5. Considerable force is at times necessary to drive a cone or race off or on. One a bit undersize will force some of the softer metal of the spindle off as it is forced on, thus cutting it down to a slightly smaller size.
6. The workman must remember that the cones and races are hardened, and striking them with a hardened hammer will very likely chip them and result in future damage.

JOB 15. REPLACING WHEEL BEARING CUPS.

The hardened steel races mounted in the front wheels for the ball bearings are called outer and inner ball cups. These are press fits. To renew proceed as follows:

1. Remove the wheel and clean it of all grease. A stream of hot water is beneficial in this work, or kerosene and a stiff paint brush may be used.
2. Insert a block of wood or a pipe through the rear of the hub as the wheel lies on a block on the bench.
3. Making certain that the drift, which is the pipe or the stick of hard wood, rests on the ball cup in the outer end of the wheel hub, it may be driven downward. This will force the cup out.
4. Having the outer ball cup out, there is more room available to drive the inner cup outward having the drift inserted from the outer hub end.
5. When the new cups are being inserted care must be used not to strike them with a steel hammer. Use a lead mallet, or a block of wood may be used as a drift.
6. Repack with grease and reassemble the wheel. Discard any broken, chipped, or undersize balls.

JOB 16. STRAIGHTENING DAMAGED FRONT AXLES.

It is quite possible to straighten front axles and use them with safety and assurance of proper service if the mechanic has proper facilities for doing the work and making the proper tests when the work is in progress. For those desiring to attempt work of this nature the following suggestions are given:

1. Remove the axle from the car, blocking the car so that there is no danger of it falling on the workmen.

2. From such portion of the axle as appears to be left in its original shape, make an estimate of the work needed to bring the sprung portions back to shape.

3. If it is a Ford axle or only sprung a slight amount, it is not advisable to heat it, instead straighten it while cold. This means, it must be placed in the garage press in such manner that the correct force may be brought to bear.

4. If the axle is one of the heavier type and rather badly damaged it may be heated at the point showing most damage. When heated to a red heat it may be caught in a heavy vise and straightened by means of pulling on the projecting end. A bending bar is of assistance in this case.

5. Avoid the use of a hammer as far as possible as the appearance as well as the actual value of the job is marred by any appreciable amount of hammering. In some cases the use of the hammer is necessary.

6. When the axle appears to be in proper shape, test by setting two framing squares on the spring perches and sighting over the blades to see if they are in alignment. If so, the central part of the axle has no twists.

7. Insert a piece of cold rolled steel in each of the yokes. Sight them to see if they are parallel. If only one end of the axle was damaged, this end should be brought to the undamaged one by applying heat between the spring seat and yoke, and after gripping the axle in the vise again, use a bending bar to twist it into alignment with the good end.

8. If both ends are thought to be out, castering must be provided to a slight extent. To test for this, sight a cold rolled steel bar fitted into the yoke with a square blade set on the spring seat. If they align there is no caster. If the top end of the cold rolled bar or pin shows at an angle with the square, the top is back of the blade and the bottom would be ahead of the blade, the axle has caster. A slight amount is all that is needed. If the reverse of the above is true the fault must be remedied or steering will be made difficult and actually unsafe.

9. In straightening and in replacing the axle the repairman must keep in mind at all times which is the front and which is the rear of the axle.

10. Unless especially equipped for such work no attempt should be made to heat, treat or temper the axle. Allow it to cool and it will be in condition to put into service. Do not cool in water.

JOB 17. REPLACING STEERING KNUCKLE BODY.

When, because of natural wear or accident, it is necessary to replace the steering knuckle spindle body, proceed as follows:

1. Jack up car, remove wheel and put aside.
2. Remove pivot bolt sometimes called "king pin" or "bolt."
3. This permits the spindle body to be lifted out of the axle yoke.
4. Remove bearing or stationary cone.
5. Fit pivot bolt into the new spindle body bushings.
6. Replace and reassemble wheel in position.

JOB 18. STEERING GEAR LUBRICATION.

One of the most important points to keep well lubricated is the steering gear mechanism. The bearing just under the steering wheel is lubricated with engine oil. The working parts in the gear case are lubricated usually by a heavy oil, or a light grease, or a mixture of engine oil and cup grease. The

type of lubricant is dependent to a certain extent on the nature of the construction.

1. Oil the top bearing. (Fig. 32.)

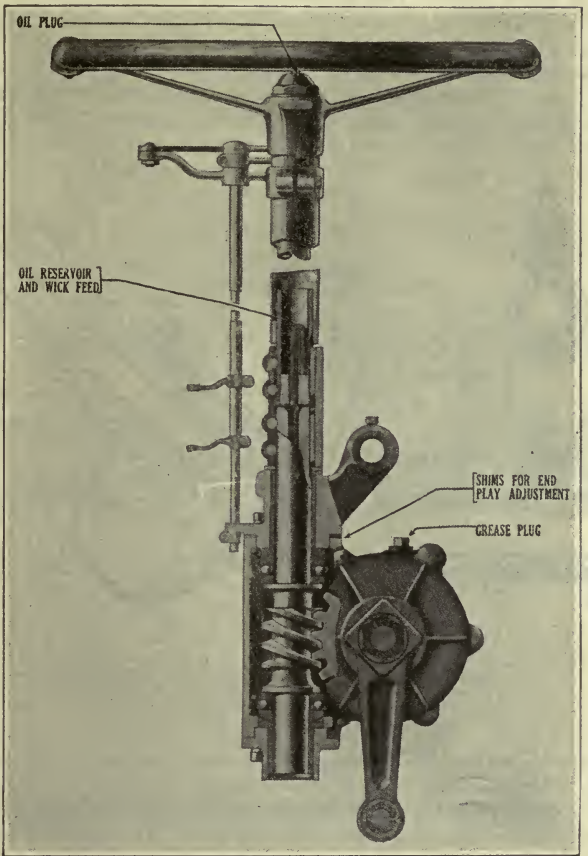


Fig. 32. Steering Gear Adjustment and Lubrication. U. S. Model.

2. Oil controls (spark and throttle)) several drops to each point ot bearing or wear.

3. Inspect gear for any other points requiring oil lubrication.

4. Fill the case with grease, or heavy oil, using the kind specified by the manufacturer.

5. Locate and fill any grease cups.

6. To lubricate the drag link it is necessary to remove the boot covering the ends. (Used in most cases.) Remove all dirt and hard grease. If in bad condition, it is well to take apart and clean before repacking. Finally replace boot after packing all parts in cup grease to insure lubrication, and exclude mud and dirt.

JOB 19. ADJUSTING STEERING GEARS.

Since the safety of the car and the occupants is dependent on the proper adjustment of the steering gear and its proper functioning, too much care cannot be given to it. The worm and gear type is provided with several adjustments, in most cases. The most common adjustment is to remove the up and down or endwise play of the worm within the housing.

1. Inspect the gear case for the locking screw nut or bolt.
2. Release the locking device.
3. With a large wrench turn the adjusting nut down on the thrust bearing until all the end play is taken out. Note Figs. 33 and 34. If no other play is

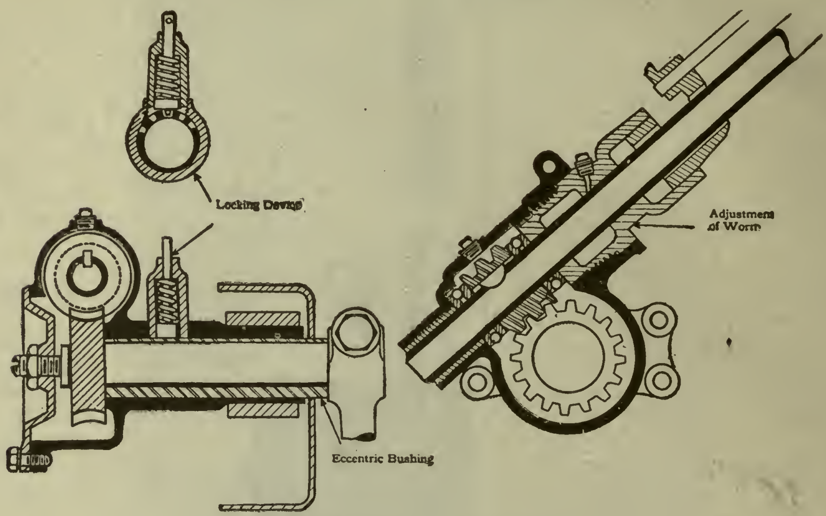


Fig. 33. Allen Steering Gear Adjustment.

evident it may be necessary to release the adjusting nut a bit to allow the required play in the steering wheel. This should be from ¾″ to 1½″.

4. Some gears, as for instance the Dodge and Allen, are provided with eccentric bushings for the gear shaft to work in. By turning these bushings which are originally assembled with the thin side next to the worm, the play between the worm and the gear may be removed and the wear compensated for. This adjustment is shown in Fig. 33.
5. Another adjustment is shown in the same figure. This is the thrust washer and screw arrangement holding the gear in position. Sometimes when this is not provided in this way it is necessary to remove the case cover and remove a thin shim thus taking the play out at that point. To prevent undue wear, none of the adjustments mentioned should be made too tight.

JOB 20. OVERHAULING DRAG LINK.

In the ends of the drag link are mounted several cups, a spring, and an adjusting screw locked by a long cotter key. This is the standard type of drag link construction. To clean and adjust proceed as follows:

1. Fig. 13 shows the steering connecting rod or drag link. Remove the cotter key from the end.

2. With a heavy screw driver remove the adjusting nut through the slot of which the cotter key is ordinarily placed.

3. Remove the hardened ball cups and the compression spring, and pull the drag link from the steering arm ball.

4. Clean all parts, inspecting same for wear.

5. Replace parts in proper order having first packed them in medium cup grease.

6. Do not draw the adjustment too tight or undue wear will result. If too loose, the steering gear is not safe and is likely to be noisy.

7. Each end is similarly constructed although not exactly alike in every case. When removing parts, note very carefully their proper relation to each other. Replace in their former order. As a rule the new adjustment will be a bit closer than the old to account for the wear.

8. Inspect and make very certain that both cotter keys are in position.

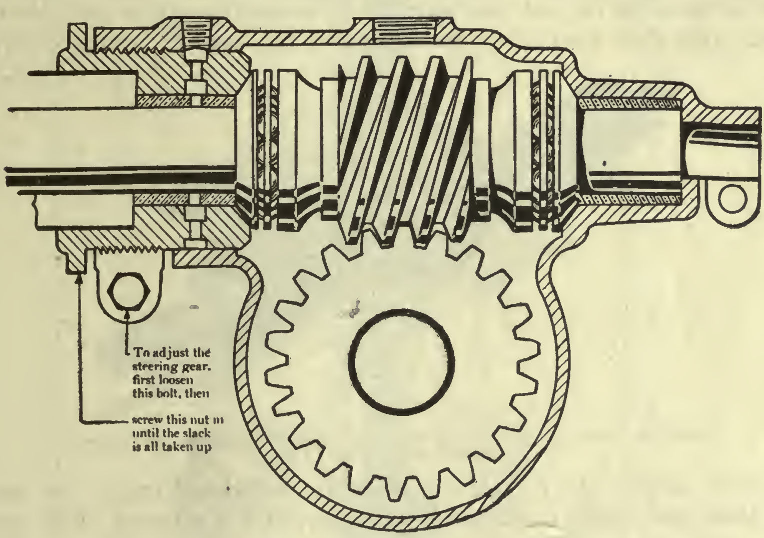


Fig. 34. Thrust Bearing Worm Adjustment.

CHAPTER 3

REAR AXLES AND BRAKES

Rear axles may be divided into two general classes, live axles and dead axles. The live axle is used universally in passenger vehicles. The dead axle is still used to some extent in trucks.

Live Axles.—As to the relative merits of live axles of various types, designers have contended for some years. Each has its peculiar advantages as well as disadvantages. These will be mentioned as the types are considered. In considering any axle to determine what type it is, one main point only need be remembered and that is whether or not the axle shaft actually carries any load or strain other than that of transmitting the turning or driving effort to

Fig. 35. Dead Axle Load Carrying Member as used on Torbensen Internal Gear Rear Axles.

the rear wheel. If it takes a load or weight directly on either end, then that end is not floated. If either end is relieved of all strain other than driving torque, then that end is floated.

Plain Live.—A plain live axle is one in which each end of the shaft is resting directly in bearings. The driving weight as transmitted from the pinion gear and differential must be born by the inner end of the shaft, while the outer end of the shaft carries directly the weight of the entire chassis body and load. The advantage of this type is lighter construction and less play in parts since all parts

Fig. 37. Live Axle Shafts.

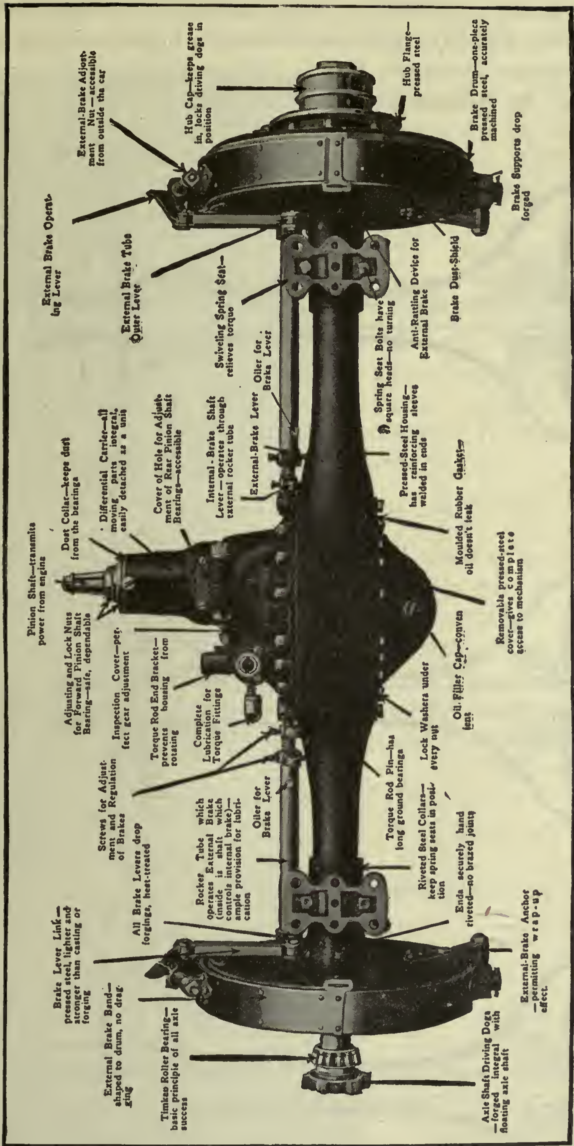


Fig. 36. Timken Detroit Full Floating Axle. with Names of Parts.

are usually keyed together. Some disadvantages are difficulty of repair and a lesser degree of safety in service. An axle shaft of this type when broken is very likely to let the wheel come off and allow the axle housing to drop to the ground. The Ford axle is representative of this type, and is a very sturdy axle for its weight. In replacing

an axle drive shaft of this type, it is necessary to remove the entire rear axle housing from the car, remove the wheels, remove the torque tube, and separate and pull the housings endwise after which the differential may be disassembled and the shaft removed.

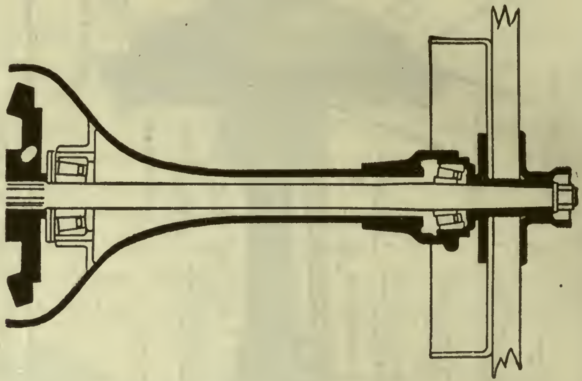


Fig. 38. Semi-Floating Axle.

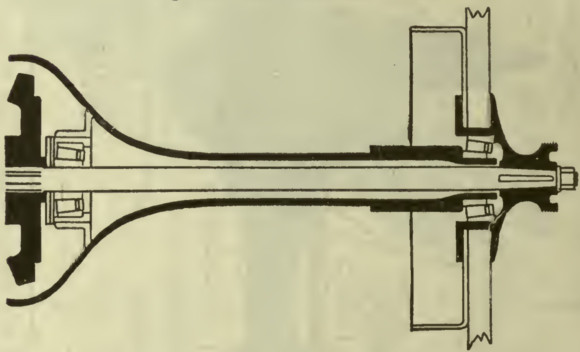


Fig. 39. Three-Quarter Floating Axle.

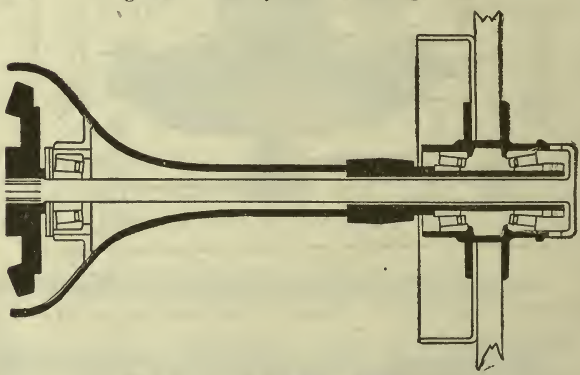


Fig. 40. Full Floating Axle Type.

Semi-Floating.—Here the outer ends are carried as in the plain live, while the inner ends rest in the differential side gears. These

are carried by the differential case, which in turn is carried by the roller or ball bearings in which it rests. This floats the inner end since it is not subjected to any shearing strain. Besides the shearing strain on the outer end the shaft is subjected to torsional strain and bending moment. Refer to Fig. 38. In some cases tension and compression may be added as the wheel bearings do not take thrust and the shaft is prevented from moving endwise only by the thrust bearings on the differential case.

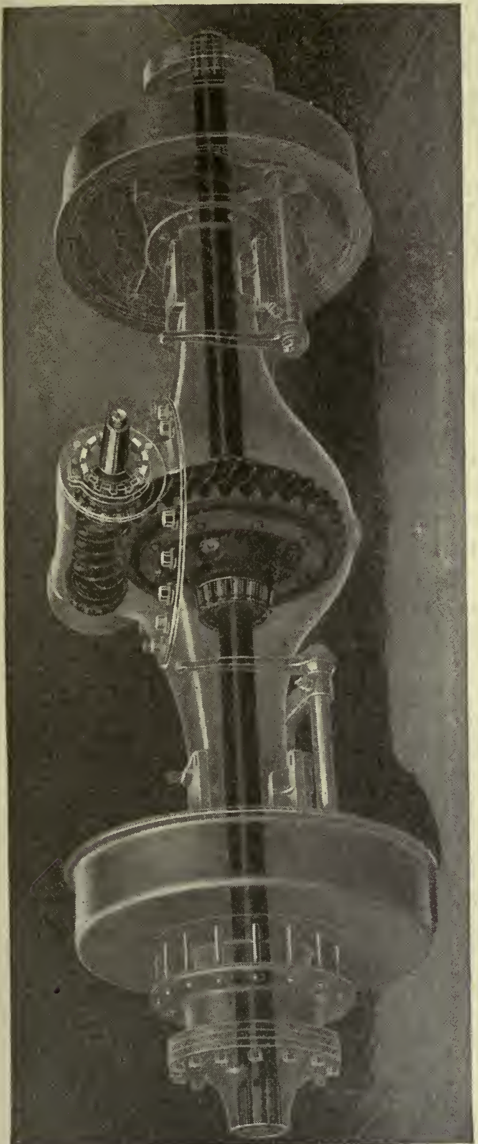


Fig. 41. Timken Detroit Worm Drive Truck Axle.

Three-Quarter Floating.—In this axle the inner end is floated as in the semi-floating while the outer end is fitted in the center of the wheel hub, which in turn has a bearing in it. This bearing fits over instead of in the axle housing thus relieving the axle shaft of the dead weight of the car. It must still hold the wheel in alignment thus preventing wobble. It must also take all skidding forces and side pressure such as are developed in rounding corners, traveling over uneven roadways, and skidding into obstructions. These forces may be many times as great as the weight of the car and passengers. This force is represented at "T", Fig. 44, as tending to bend the axle out of shape. To actually prevent such bending the housing and shaft are designed with a fair margin of safety. This type still carries the end strains of tension and compression in most cases.

Full Floating.—In this case the shaft is relieved of all loads or

stresses excepting that of turning the wheel or torsion. The inner end is floated as described for the semi-floating while the outer end is floated by applying two bearings on the housing within the wheel hub, instead of the single bearing in the three-quarter floating. These two bearings may be said to carry the load and align the wheel in much the same manner that the bearings within the front wheel hub perform their duty. The shaft serves only to transmit power to the wheel to turn it.

In this construction the inner end of the shaft is splined or milled square. The hubs of the side gears are machined to fit these ends, enough clearance being allowed to insure of an easy fit. That is, they may be pulled out or forced in by hand without driving or pressing. The outer end is either fitted rigidly to a flange which is in turn bolted to the road wheel, or is fitted with a dog clutch. In either case the axle drive shaft may be removed without disturbing the road wheel.

The advantages of the semi-floating type are a rigid construction permitting of little lost motion or play between parts.

It is not so quickly or easily repaired as it requires the use of a garage press to remove certain parts. In some cases the axle housing must be removed from under the car and completely disassembled to replace the shaft or other broken parts.

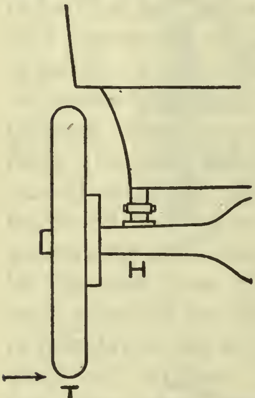


Fig. 42. Rear axles must be so designed as to maintain this position at the same time carrying the load, turning the wheels, and resisting the skidding or side sway effect.

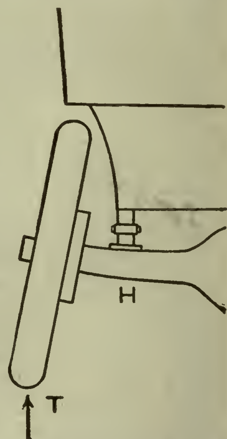


Fig. 43. Weight of car and load has tendency to spring axle as shown.

The advantage of the three-quarter floating over the plain live or semi-floating is that the outer end of the shaft is now relieved of the shearing strain due to the weight of the car. Axle shafts are less likely to be broken, and if broken the car is less likely to drop to the road. In one construction the wheel could not come off. The disadvantages are about the same as for the plain live or semi-floating. Replacement of a broken shaft, or other parts, is likely to entail a great deal of work. In some cases the construction permits of the shaft being pulled without removing the housing from the car; in others it does not.

The advantages of the full floating are the greatest possible factor of safety and ease of replacement of parts. There is no possibility of the car dropping to the ground in case of a broken shaft. The housing is often of one-piece construction, allowing room on the rear

of the differential housing for the entire differential assembly to be removed, after the shafts have been removed from the ends. Quick repairs and easy adjustments are thus possible. The greatest disadvantage is the liability of parts becoming worn where a slip fit is used and in time a harmful amount of back lash appears.

Live Axle Types of Drive.—The line of flow of power in the live axle is, in most cases, from the propeller shaft to the pinion gear, pinion gear to bevel gear, bevel gear to differential case, differential case to differential spider, differential spider to spider pinion, spider pinion to differential side gear, side gear to axle shaft, axle shaft to wheel, wheel to road. This will vary somewhat in cases of special construction.

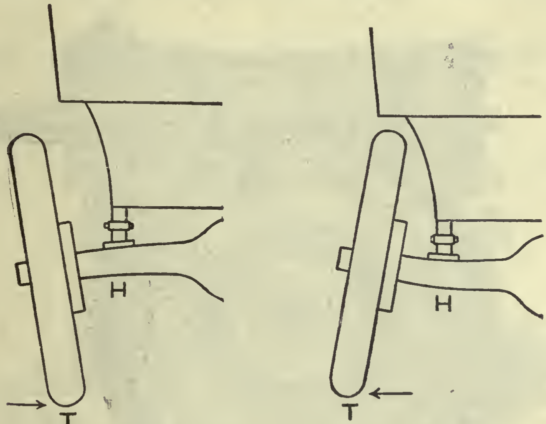


Fig. 44. Skidding tends to bend the axle as shown.

Bevel Gear and Pinion.—The plain bevel gear and pinion are used rather extensively in light cars, while the spiral gear and pinion are used in passenger vehicles of the heavier type. The advantage secured is more teeth in contact at the same time, giving a more even flow of power as well as less liability of fractured teeth due to all the strain coming on one tooth.

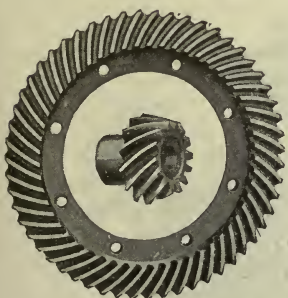


Fig. 45. Spiral Bevel Gear and Pinion.

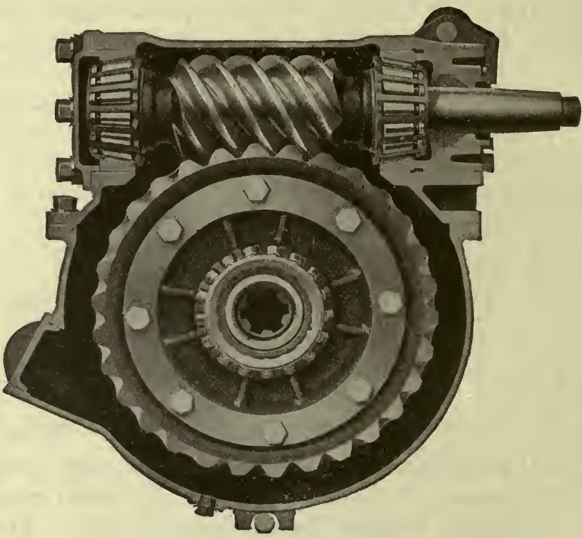
The gear ratio of pinion and bevel gear is rather fixed within certain limits, four of the propeller shaft to one of the rear axle shaft being an average. Almost all cars of standard passenger type would fall between three and one-half to one which is a high ratio, to four and one-half to one which is a low ratio. The trend however is toward still lower gear ratios, and five to one is gaining favor.

In the worm and gear drive the gear ratio is much lower as in the Ford where it is approximately eight to one.

Worm and Gear.—The worm and gear is used in a large number of truck axles. The advantages of this drive are gear reduction and ability to perform continuous heavy duty with a minimum of lost power. Since all parts are enclosed, well lubricated and kept free of foreign matter, the liability of failure is greatly reduced. For this reason, and for the sake of quiet and increased efficiency, this type of drive on live axles for trucks has largely superceded the double chain drive on the dead axle.

Single Chain Drive for live axles is practically extinct.

Dead Axle Drive.—As mentioned previously the dead axle has been used in trucks because of its carrying ability. Formerly a large share of trucks were equipped with dead axles and double chain drive.



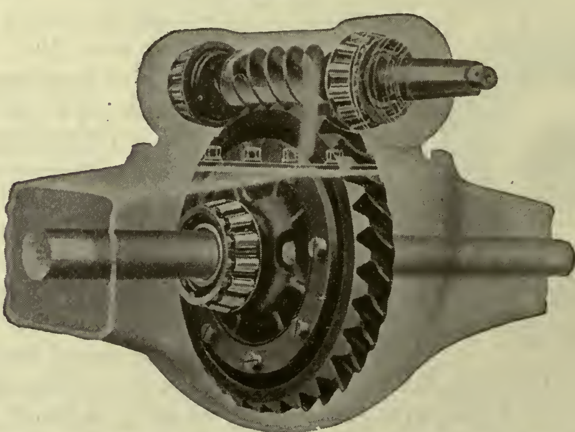


Fig. 46. Two views of Worm and Gear as used in Truck Axle Drive.

A constantly decreasing number of manufacturers are using the chain drive. This is due to trouble with the chains and the fact that the

Fig. 47. Typical chain drive equipment showing dead rear axle chain, sprockets and jack shaft.

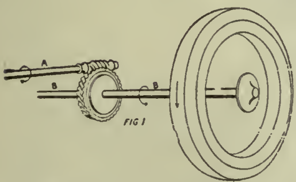


Fig. 48. Illustrating Worm drive principle.

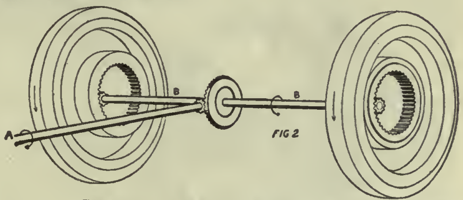


Fig. 49. Sketch showing internal gear drive principle.

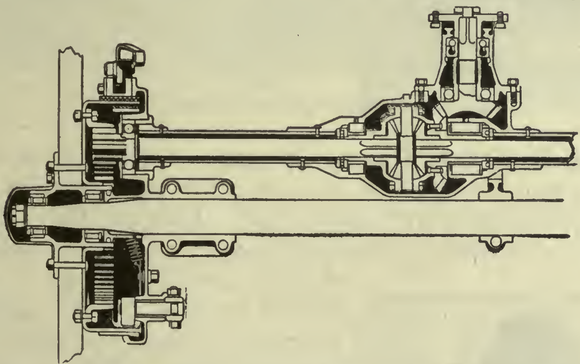


Fig. 50. Cross section of internal gear rear axle construction.

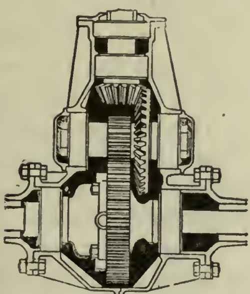


Fig. 51. Double Reduction Gears as used in Rear Axle Drive.

moving parts are exposed to the dirt, dust and other foreign materials which result in wear and breakage.

Internal Gear Drive.—In this case a large internal gear replaces the sprocket of chain drive type on the rear wheel. The power is transmitted from the differential to the internal gear through a live shaft mounted in conjunction with the dead axle. All parts are enclosed as a rule to keep out dust and dirt and improve lubrication. As in the chain driven truck the percentage of power transmitted to the road wheel is high. Trucks of all ranges of capacity are being fitted with this type of rear axle.

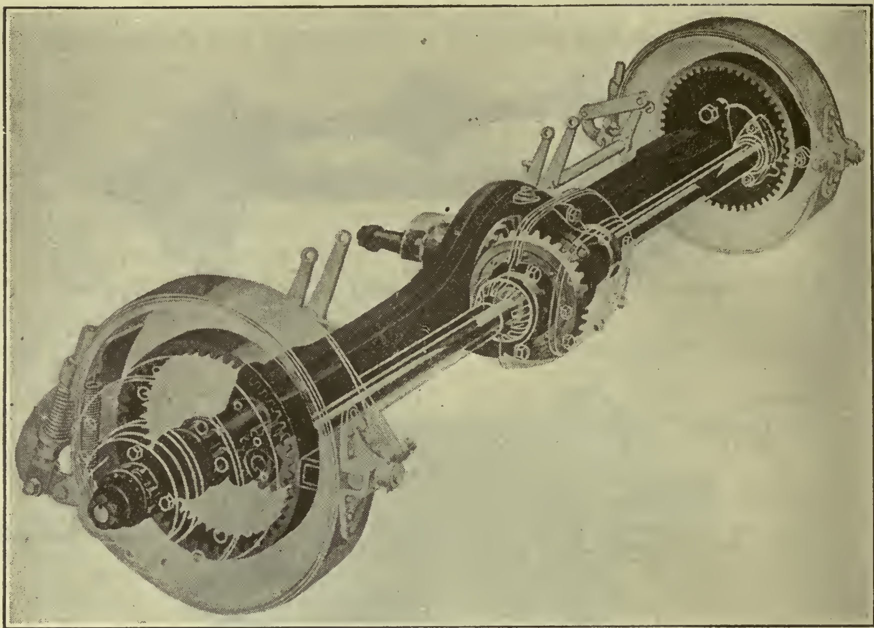


Fig. 52. Torbensen Internal Gear Rear Axle.

Double Reduction Gears.—In some cases of live axles double reduction gears are used to so reduce the gear ratio as to give the proper gearing for heavy duty work. Part of the reduction as in other types is secured by the difference in size of the pinion and ring or bevel gears. Another or added reduction is secured by the addition of the spur gears where the smaller is used to drive the larger. Refer to Fig. 51. The large spur gear is mounted in the place of the bevel gear on the differential. This type of rear axle gearing has more parts than the worm drive axle of similar rated capacity. It has more bearings and gears to be kept in proper alignment and adjustment.

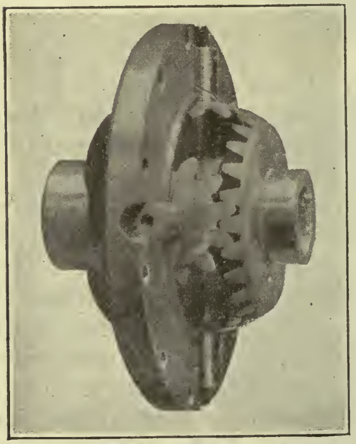


Fig. 53. Differential Assembled in One-half of the Differential Case.

Differential Construction.—The rear axle shafts are independent of each other, one being termed a right and the other a left-hand shaft. This is necessary to permit of rounding curves when one wheel is turning faster than the other. For the same reason, and to

transmit power equally to these wheels even though it be at different speeds, it is necessary to provide the differential. The differential does deliver the same amount of power to each wheel irrespective of the speed.

To accomplish this the differential case has been designed to carry the ring or bevel gear from which it takes the power transmitted to it from the engine through the transmission, propellor

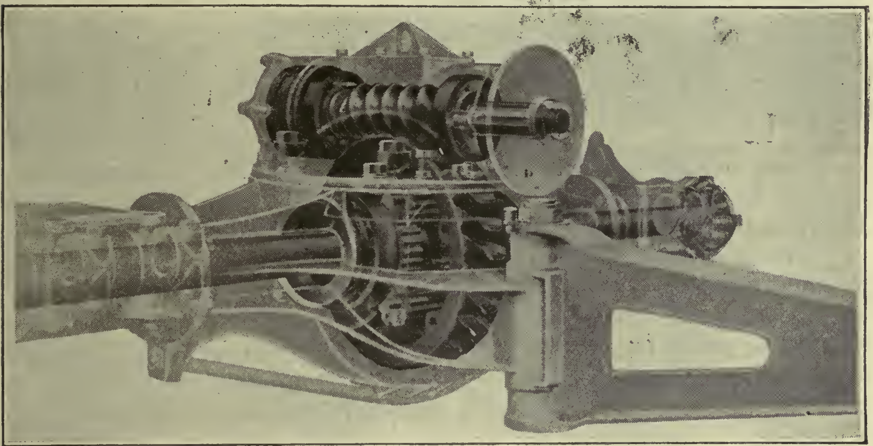


Fig. 54. Spur Gear Differential as used in Packard Truck Axle.

shaft and ring gear. Receiving the power from the ring gear the differential case transmits it to the spider on which are mounted the spider pinions. In the spider pinion is found the real means for flexible power transmission. These are meshed on either side with the two differential side gears. On a straight drive the differential case, spider, spider pinions, and side gears revolve as one solid mass. That is, there is no internal movement of any of the parts within the case. In rounding a corner, or a curve, one side gear is slowed up because the wheel to which it is directly connected with the axle drive shaft is slowed. The other side gear is speeded up because the wheel to which it is directly connected is speeded since it has farther to travel to round the curve or corner. The spider pinions being free to rotate on the pinions will do so to the extent necessary to compensate for the difference in speed. While still delivering power from the ring gear to the side gears as the differential case revolves, the movement of the pinions within the case permits of the needed difference of speed of the opposed side gears. If turning to the left they rotate on their pivots or pinions in one direction, turning to the right they will be caused to rotate in the other direction.

Whenever one wheel has less traction than the other it is likely to start spinning. No more power can be transmitted to the other

Fig. 55. Powerlock Differential used to prevent one wheel spinning in mud or other bad going.

wheel than is needed to start and keep the first one spinning. To get out of a bad place in the road, as in traveling through mud, both wheels must hold equally or have nearly equal traction. Certain devices are in use in the differential which permit the automatic locking of the differential gears in cases where there is a tendency for the wheels to spin. This is almost invaluable where heavy hauling through mud is being done. Refer to Fig. 55.

The action of the differential might be compared to a team of horses hitched to a double tree and drawing a loaded wagon. One may go ahead or the other may go ahead, but always when one goes ahead the other falls back. The differential is an endless equalizer or evener.

The following description of the character and functions of the differential is taken from the Timken Primer:

The differential consists of a set of bevel gears located at the center of the rear axle. Its purpose is to divide the power transmitted from the engine equally between the two wheels, and to do this in such a way that one wheel may revolve faster than the other when necessary.

In a wagon the rear wheels are mounted on a dead axle and revolve independently of each other. There is, therefore, no need for a differential. In a power-driven vehicle the rear wheels must still revolve independently and yet each must receive one-half of the power transmitted through the rear axle.

To illustrate the principle in as simple a manner as possible we show in Fig. 56 an experimental apparatus in which A—A' are the two live axle shafts to whose outer ends are fastened the wheels W—W'.

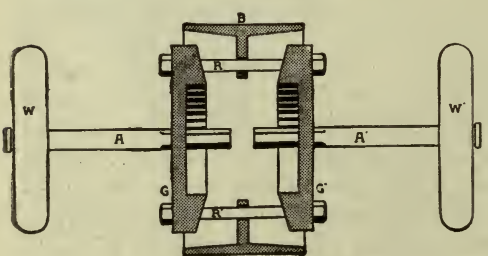


Fig. 56.

Mounted on the inner ends of the shafts A—A' are the bevel bears G—G'. Surrounding these gears and concentric with them is a belt-driven pulley B.

It will be clear that if

we connect the two gears solidly by the rods R—R', which in turn are securely fastened in the web of the pulley B. Movement of pulley B will cause both the gears G—G' to revolve at the same speed in the same direction; and, since the wheels W—W' are, like the gears G—G', secured to the shafts A—A', the wheels will also revolve at the same speed in the same direction.

Now, to allow the wheels W—W', and, therefore, the gears G—G', to revolve at different speeds, we remove the rods R—R' binding the two gears together and substitute for these rods the pinions shown in Fig. 57. These pinions rotate freely on the web of pulley B and their teeth are in mesh with the teeth of the bevel gears G—G'.

It is clear that when the pulley B revolves, its motion is transmitted through the pinions to the gears G—G' and on through the axles A—A' to the wheels W—W' just as it was transmitted in the apparatus shown in Fig. 56, but with this important difference—if wheel W is now prevented from revolving, the pinions will rotate on the web and thus allow the gear G' to revolve, carrying with it axle A' and wheel W'.

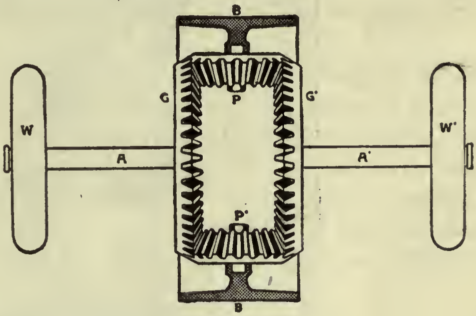


Fig. 57.

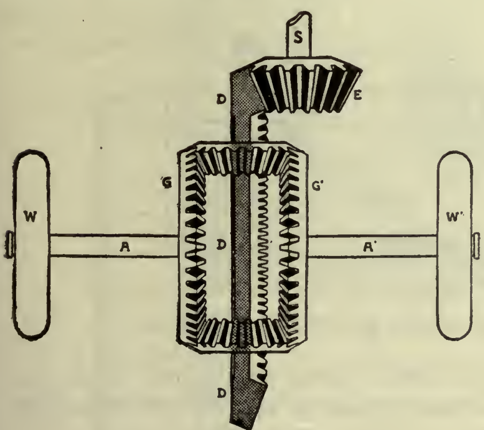


Fig. 58.

If gear G revolves slowly, gear G' can revolve rapidly, or vice versa, because the difference in their motion is compensated for by the rotation of pinions P—P'.

It will also be clear that in all cases the pressure transmitted from the pulley B through the pinions P—P' to the teeth of the gear G and the gear G' will be equal, because the distances between the centers of the pinions and the teeth of both gears are always equal.

In the simplest language possible, when gear G remains stationary, gear G' and the pinions roll around, as it were, on gear G, the

teeth of the pinions pressing forward on the teeth of gears G and G' with equal pressure.

Referring now to Fig. 58, we see the differential as actually used in the rear axle. In place of pulley B in Figs. 56 and 57 we have the driving gear D, and instead of two pinions there are now four, but the action is the same as that described for the apparatus in Fig. 57.

The driving gear D receives the power from a beveled gear

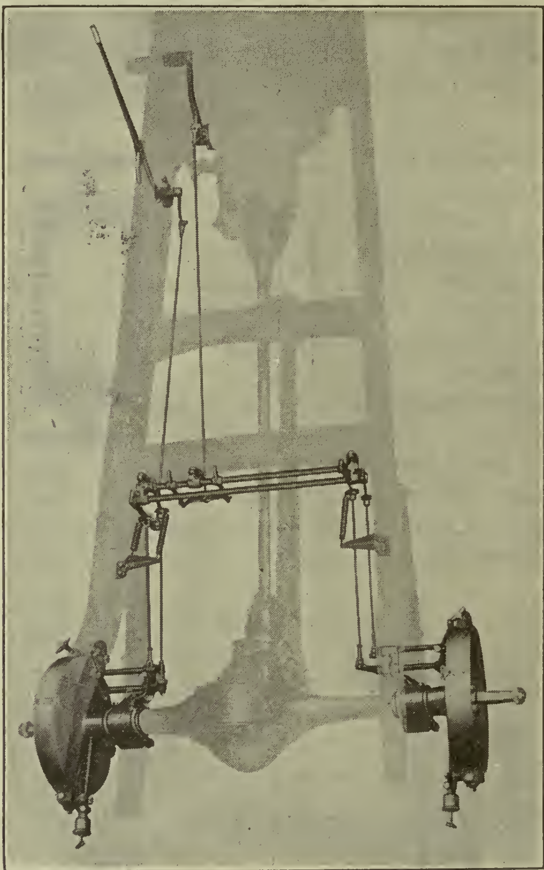


Fig. 59. Packard Twin Six Brakes and Braking Mechanism.

known as the driving-pinion, the latter being at the rear end of a "pinion-shaft" coupled with the main propeller shaft which transmits the power from the engine.

Rear Axle Trouble.—Most common of all rear axle faults is that of broken teeth in ring or pinion gears. There are many causes of this trouble chief of which are poor driving and poor adjustment of

the gears. The latter trouble is one which will develop with normal use and may often be obviated by a system of regular inspection. Care in the application of power will do much to save gears.

Transmitting the power from a modern high powered engine to the rear axle throws an almost inconceivable strain on just one or two teeth of the ring and pinion gears. There should never be less than two teeth engaged at the same time and in certain cases three teeth. If thrust bearings are badly worn this may not be the case and only one tooth may be in contact. When this condition exists it will be found that the tooth taking the load receives it on its outer end and trouble is likely to develop quickly. On a hard pull the teeth will chip and crack. Pieces broken out come in between the other teeth and further damage is caused. In the latter case bearings are very likely to be crushed.

When a rear axle has developed trouble no further effort to drive the car under its own power should be made until an effort is made to relieve the trouble. The car, if possible, should be towed in to the service station. In certain instances this may be as bad or worse than driving unless care is used to prevent the axle parts turning. To do this remove axle drive shafts, or, if the frozen type, remove the keys from the wheel hubs. In case this is not possible a "dolly" should be resorted to.

BRAKES

The proper care and adjustment of brakes is one too often overlooked. It is far more essential to stop a car quickly at certain times than it is to start it quickly or accelerate rapidly. The energy stored in the car by the engine must ofttimes be quickly overcome by the

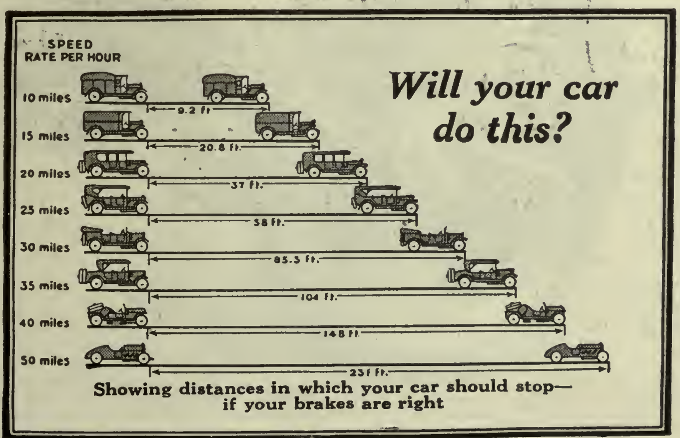


Fig. 60. Chart Showing Brake Efficiency Tests.

brakes. The power generated by the engine in climbing a hill must be equaled by the gripping power of the brakes in coming down the hill. The engine is used to start the car, to pull it over the road, and to develop energy. The brakes are used to overcome momentum and gravity.

Braking Surface.—The number of square inches of braking surface found on the brakes of the car bears rather a direct relation to the weight and power of the car. A certain factor of safety is allowed. The chart shown in Fig. 60 illustrates the distance which the Thermoid Rubber Company's engineers have figured as correct for a test of a brake's efficiency. At 30 miles per hour the brakes should be able to bring the car to a stop in 83.3 feet. The speed of 30 miles per hour represents a speed of 44 feet per second. Brakes must act quickly and positively to make this possible. Brake lining may be judged in part by the construction of the weave. The closer the texture the more braking surface actually in contact with the brake drums.

Types of Brakes.—The most generally used type of brake is the one having a brake drum mounted on the rear wheel. This brake drum usually has a brake band arranged to contract on its outer surface and another band or shoe arranged to expand on its inside. Both bands are lined with a heat resisting friction producing material. This arrangement permits of two separate braking effects on the same drum.

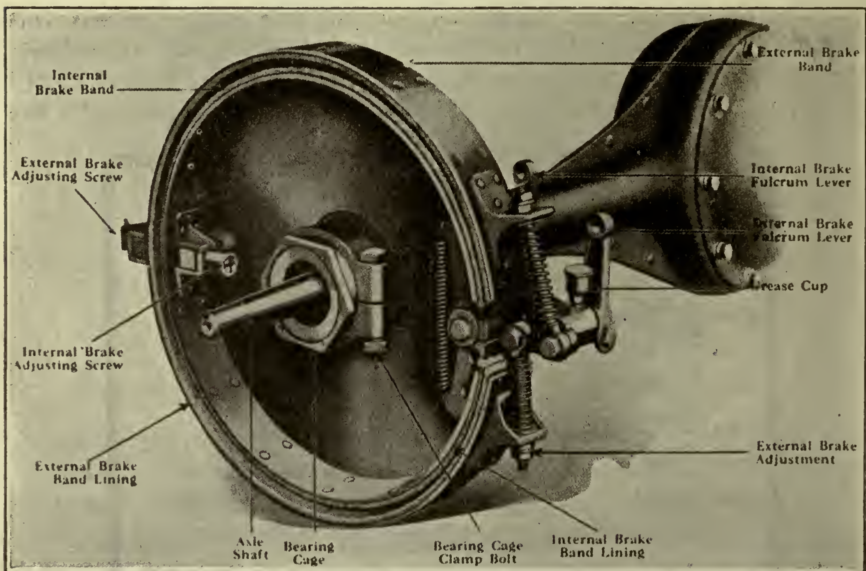


Fig. 61. Typical Passenger Car Brakes.

Double Width Drum.—In this case the brake bands are assembled side by side. Both are external contracting or internal expanding, usually the latter as this permits of them being kept clean and dry. Grease and oil working out from the axle housing is likely to cause the internal type to lose its braking efficiency. When this happens, the wheel should be removed, the grease and oil washed or burned out, the drum cleaned, and then reassembled.

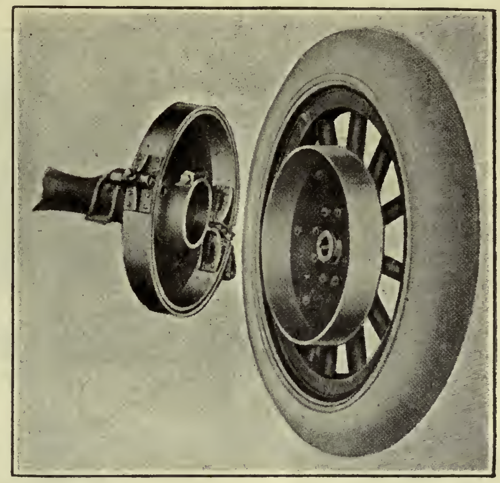


Fig 62. Brake Drum Mounted on Rear Wheel.

Transmission Brakes.—In the Ford car a brake drum is placed on the driving plate which is always turning when the rear wheels are in motion. Applying the brake band to this drum by depressing the brake lever checks the speed of the car. Since the gear ratio through the rear axle is approximately 4 to 1, the braking effect is four times as powerful at this point as it would be if applied to the same size drum and band on the rear wheel. One bad feature of the transmission brake is the lack of understanding of this feature. A sudden forceful application of the brake throws a tremendous strain on the ring and pinion gears as well as other axle parts. At times this results in breakage and complete loss of control of the car.

Another undesirable feature of the transmission brake is the danger of skidding if one wheel has a good dry road grip and the other is on ice or a wet portion of the roadway. In this case the sudden application of the brake which locks the propeller shaft will cause a rapid spinning backward of the wheel on the slippery portion while the car skids sidewise or continues to move forward. This action of the differential is the same as occurs when pulling through bad places in the road and only one wheel has traction and the other spins.

The transmission brake is used on other chassis besides the Ford. It is used on a number of passenger vehicles and has met with a degree of favor on commercial cars. The drum is mounted on the outside to the rear of the transmission case and may be used either in connection with the foot or hand brake. Fig. 63.

Brake Shoes.—In certain cases a metal shoe without any lining

is used as an internal expanding brake. This type is almost obsolete having been superseded by the internal expanding band type on which a fabricated lining is riveted.

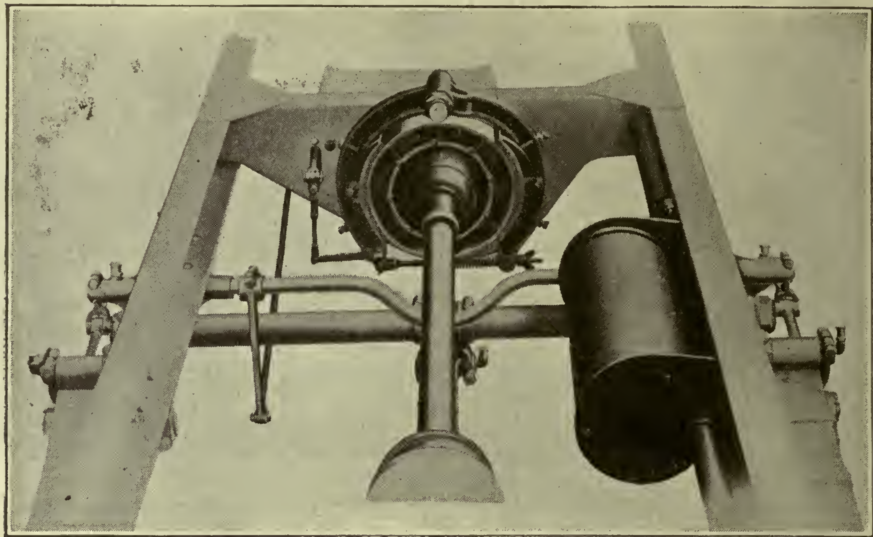


Fig. 63. Packard Truck Transmission Brake and Drum.

Brake Names.—The usual practice is to connect the hand brake (not emergency brake) to the internal expanding bands, and the foot brake (not service brake) to the external contracting bands.

Brake Equalizers.—Equalizers are used by some car manufacturers and discredited by others. The idea of the equalizer is to automatically apportion the same braking effort to each of the rear wheels much as the two horse evener permits of each horse drawing half the load. It has the disadvantage of putting both brakes of any set out of commission if there is a break on either side. On the other hand there is far less danger of the brakes gripping or wearing unevenly in continued service, and far less skill is needed to secure a fair adjustment. The fixed type of adjustment, where each side is actuated in a fixed relation to the brake levers, permits of one side being used after the other may have become broken or damaged in such manner as to make it useless. This type requires expert skill and judgment in adjusting for wear. If one side is set to act more quickly than the other the car will skid to the side whenever the brakes are applied suddenly.

JOB 21. ADJUSTING EXTERNAL BRAKE BANDS.

In all brake adjustment and service two prime points must be remembered. The brake must be so set and connected to the hand or foot lever that action

is certain and sure when it is desired to stop the car. It is not so essential that the bands grip the wheels until they will slide, as it is that they will exert a firm even pressure all the way about the drum and give that ideal braking effect which is just under the point needed to start the wheels sliding on a dry roadway. Once a wheel starts to slide the brakes should be instantly released as this is a dangerous condition and the momentum of the car will carry it much farther with the wheels sliding than when they are rolling over the roadway with the proper gripping effect on it.

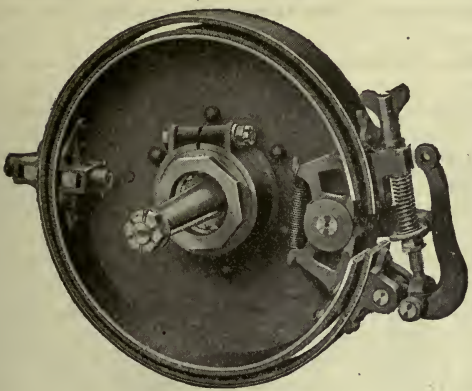


Fig. 64. Timken Cam Brake.

The second point to be remembered is that the brakes must be so set that they will not drag and consume a needless amount of power which may result in burned brakes and an overheated motor.

Practically all brakes operating on the rear wheel drums are of the same general construction. The adjustments are to be made along the following lines:

1. Jack up the rear wheels so that each is free of the floor. It is essential to have both wheels free at the same time. Since two jacks leave the job a little unsteady it is well to block up one side with wood blocks, a trestle, or like arrangement. This permits of shaking and pulling on the brake parts without danger of the car dropping from the jacks.

2. Inspect the entire braking mechanism to learn its general condition and see where the lack of proper braking effect lies.

3. Note if the brake pedal has the proper travel.

4. Note if the brake band is worn badly.

5. Note if the brake drum has any grease on it.

6. Note whether the brake band fits evenly around the drum.

7. Have a helper press the foot pedal forward, noting whether the upper and lower halves are gripping equally, or whether, due to poor adjustment, the upper or lower half of the band only is operative.

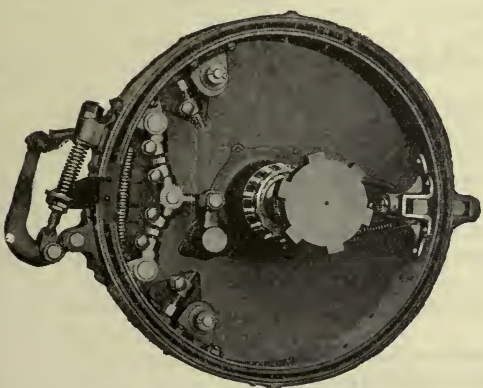


Fig. 65. Timken Toggle Brake.

8. Have the helper set the pedal at a certain point, while each wheel is tested to see if the braking effect is properly equalized.

9. Inspect all springs to see that they are operating properly.

10. Having made the above inspection the brakes may be adjusted where needed. If the entire job must be gone over proceed as follows:

11. Set the adjusting screw

at the rear of the brake band until the clearance between the drum and band is from 1/64″ to 1/32″. This will insure the brake being free at that point.

12. Adjust the center top adjustment, if one is provided, to have the same clearance.

13. Adjust the center bottom adjustment, if there is such, until the clearance there is the same again.

14. At the front end of the lower half is usually found a pair of lock or jam nuts. These should now be adjusted until the proper clearance of 1/64″ to 1/32″ is shown on all of the lower half of the band.

15. The upper end of the brake band is now drawn down by means of the thumb nut until the proper clearance shows all the way along the top half of the band.

16. With the band properly fitted to the drum the next adjustment to make is that of the pull rods and clevises. It is very essential in making adjustments on the pull rods not to bring the levers on the equalizing bar at the center of the car past centers. Rather leave them back of center so that the application of the brake fully will leave them in a vertical position. For this reason it is best to take up the rear rod rather than the forward one. Fig. 66 shows the right and wrong method.

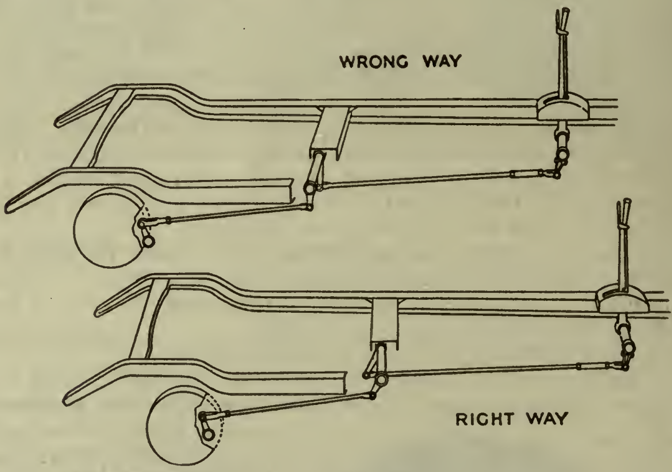


Fig. 66. Methods of Adjusting Pull Rods (Hudson).

JOB 22. ADJUSTING INTERNAL EXPANDING BRAKES.

Two types of internal expanding brakes are in common use. The first and most common is the type expanded by means of a cam, and the second is the toggle type. Either type may or may not be adjustable within the drum. Where no adjustment is provided within the drum all adjustment to take up wear must be made on the clevises under the floor boards or on the pull rods. In doing this work it is necessary to proceed as follows:

1. Jack and block both sides of the axle to hold the wheels free of the floor.

2. Remove the wheels. (Refer to Jobs 21 and 29.)

3. Inspect the lining and free it of all grease or oil.

4. Note whether an inner adjustment is provided as that shown in Fig. 65.

5. Where an inner adjustment is provided it should be set so as to overcome any unnecessary clearance. The wheel will have to be placed on a

number of times possibly, to secure just the proper adjustment. It is well to have the pull-rod clevis dropped for this work.

6. Next adjust the pull-rod clevis until all the slack is out of it, and with the lever in "off" position the clevis pin may be replaced.

7. Test the wheel for drag.

8. Test the wheel for braking effect.

9. In case there is no inner adjustment the pull rods alone must be

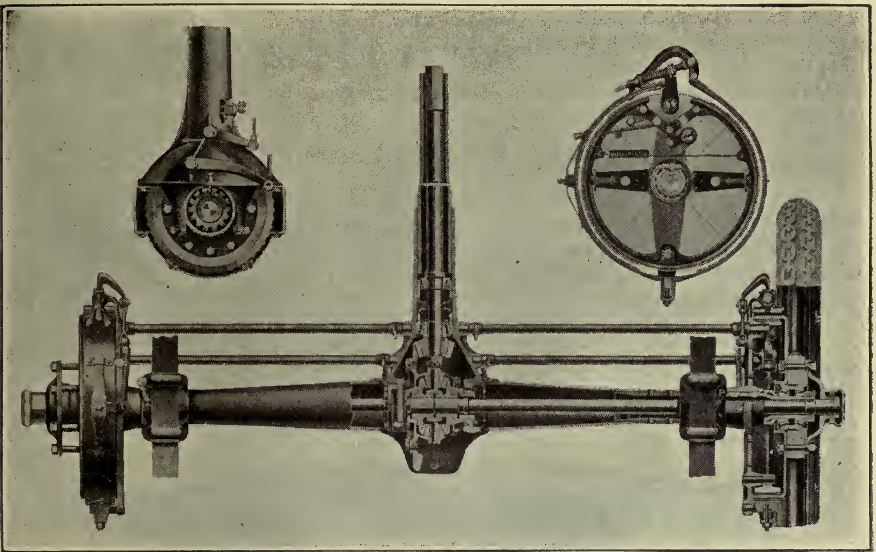


Fig. 67. Dodge Rear Axle and Brake Adjustments.

depended on. When they no longer hold, and permit of no further adjustment, it is usually necessary to reline the bands or shoes.

10. It sometimes happens that the adjustment is entirely up and that the lining is still good. To provide more take-up the brake pull rods are removed and additional threads cut on them.

11. Test wheels for braking effect. Make certain that the brakes are sufficiently firm to hold the car on any grade. Note also any tendency to drag or to grab.

JOB 23. REMOVING GREASE AND OIL FROM BRAKES.

1. Jack up the rear axle. Block car to make secure.

2. Pull wheels. (Job 29.)

3. Remove both inner and outer brake bands if such are used.

4. Take the bands to the bench or cleaning trough where they may be cleaned with gasoline or kerosene.

5. Learn the cause of the grease working out from the axle housing into the brake drum.

6. If the housing has oil above the specified level which is even with the filling plug, or about one-third full in most cases, it must be allowed to drain off.

7. If the trouble is with the felt washers in the bearing mounting they must be replaced.

8. Sometimes grease will work under or through bearing races. A soft rag wrapped properly under the bearing cup will sometimes correct the trouble.

9. Where the brake lining is of a porous nature the oil is likely to saturate the lining to such an extent that it is impossible to wash it out. In this case the gasoline torch or the welding flame may be used to heat the lining and thus dry it out. As the grease or oil is forced out by the heat it will burn with a yellowish flame.

10. With a very hot flame of this nature it is quite possible to burn the lining. In no case should it be heated until it starts to glow. In fact, heating at all is to be discouraged except in the case of linings so saturated that nothing else will correct the trouble. If this work is done with the bands in place the operator should have a fire extinguisher at hand.

JOB 24. RELINING BRAKES.

The job of lining brakes is readily done if a few vital points are remembered. Selection of brake lining is a matter for the car owner to settle but he should be encouraged to put on a good standard product. Experienced drivers know so well the value of good lining and good brakes that they are willing to pay the price for them.

1. Jack up the car and block securely.
2. Pull the rear wheels. Place parts where they will be safe and kept free from dirt, especially the bearings.
3. Remove the brake bands or shoes.
4. Measure the width of the old lining and estimate the probable thickness

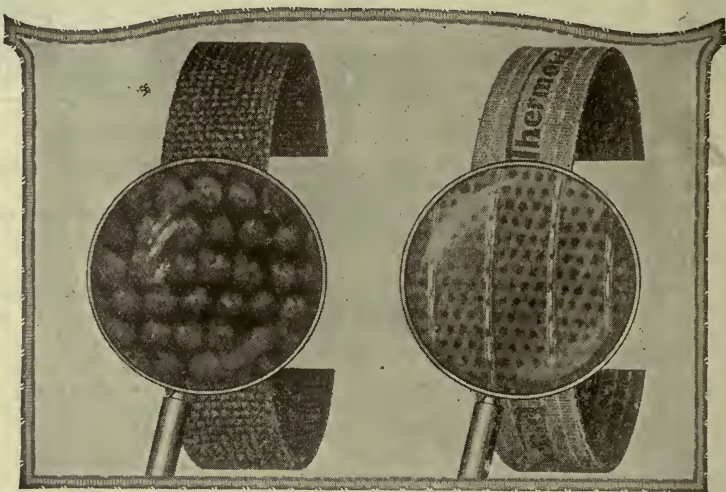


Fig. 68. Brake Lining Surfaces.

of it in its original form. Consult the manufacturers specifications if in doubt.

5. Measure the length and order the exact amount needed.
6. Remove all old lining from all the bands. Remove all old rivets, rust, dirt and grease.
7. Fit in and cut all pieces for the bands.
8. In lining the internal bands or shoes the lining is first placed on the

band, drawn tight and clamped at each end. If no clamps are at hand several stove bolts may be used to hold the lining in position. Next take a punch to mark the lining, marking from the inside out, unless it is possible to use the hand drill to drill immediately.

9. Remove the marked band and drill each point marked with a 5/32″ or 3/16″ drill depending on the size rivet used.

10. Countersink for rivet heads, if necessary, and replace the lining in position.

11. In riveting where solid rivets are used, as they are in most cases, the head should be rested on the end of a blunt punch or bolt while the end is being riveted over.

12. Do not attempt to hammer the end over flat, but give it a few sharp blows to upset it in the band and form a burr too large to prevent it being pulled out.

13. In selecting rivets for any particular piece of work they should extend through the band a distance equal to the thickness of the rivet.

14. Under no circumstances should any but a soft copper rivet be used. These may be secured from the supply houses.

15. In lining the external bands care must be used to make the lining lay close to the band. In no case must it be permitted to buckle, nor must it be too short else the lining will not conform to the curve of the band and drum, with the result that it is impossible to prevent the brakes from dragging.

16. Some mechanics make the practice of riveting each end to the lining in place as the first step, allowing a slight buckle of the lining inward. After the ends are secured this small buckle is hammered out thus insuring an even laying lining. This buckle must not be left until all but a few rivets are in, or difficulty will be experienced in getting it out.

17. The careful mechanic will make certain the rivet heads are all below the surface of the lining.

JOB 25. SQUEAKING BRAKES.

Most cases of brake squeaks can be removed by properly aligning the band on the drum and readjusting. In some cases the trouble can not thus be

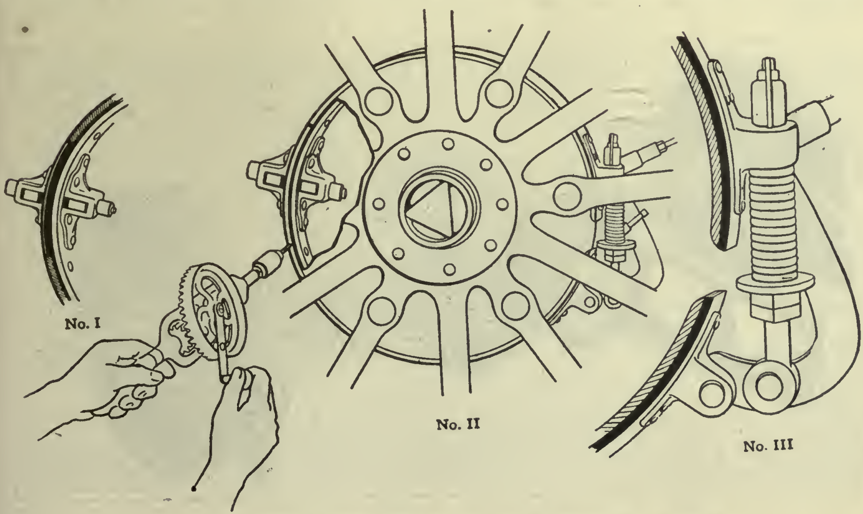


Fig. 69.

remedied. Hudson engineers recommend the method illustrated in Fig. 69 for correcting this fault. In fact, the practice of leaving out a piece of lining at the rear of the band when relining brakes is meeting with much favor. To remove the objectionable piece proceed as follows.

1. Set the brakes.
2. Select a drill just slightly smaller than the thickness of the lining.
3. Drill between the band and the drum at the two points indicated.
4. Remove the piece of lining thus cut loose.

JOB 26. ADJUSTING PACKARD TWIN SIX FOOT BRAKES.

Refer to Figs. 70 and 77.

The foot pedal is connected with the external brake bands. The clearance allowed between the bands and the drum is 1/32″ all the way around.

1. Adjust the nut on the rear support until the clearance is proper at that point.

2. Adjust the two nuts on the shank of the clevis just below the eyebolt at the front of the brake until the distance between the lower half of the brake band and the drum is also $\frac{1}{32}$″.

3. Adjust the "T" handle which operates the adjusting screw until there is a clearance of $\frac{1}{32}$″ between the upper half of the band and the drum.

4. To check for equalization make sure that, with brakes released, the brake pedal connecting rod is so adjusted that the stops on the equalizer levers just clear the rear of the rear cross channel when the pedal is against the floor board. The connection from the brake cross shaft to the rear axle should be so adjusted that the clevis pins at the upper end of the brake toggle levers clear the band by ⅛″ on each wheel. This insures proper equalization.

The equalizer bar should ordinarily be set in the upper holes of the equalizer levers. For city and for moderate speed driving they may be set in the lower holes thus reducing the effort required to obtain a given braking result.

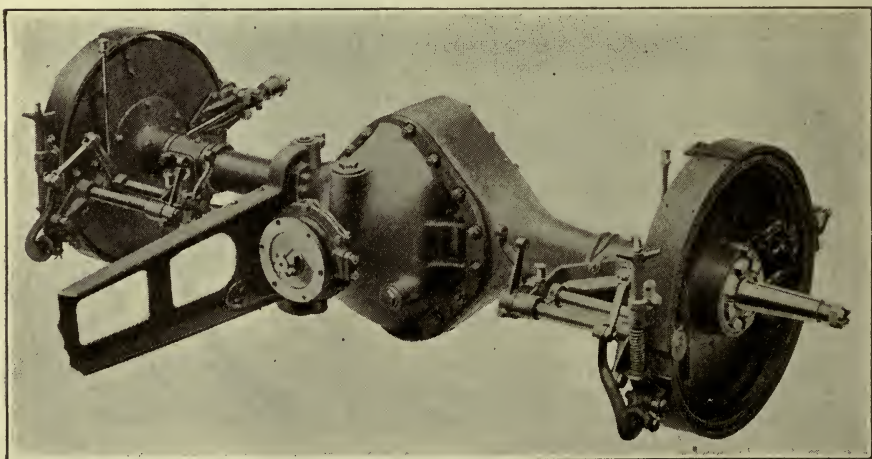


Fig. 70. Packard Twin Six, Rear Axle and Brakes.

JOB 27. ADJUSTING PACKARD TWIN SIX HAND BRAKES.

The hand brake lever controls the internal expanding brake shoes. These must be so adjusted that when applied there is the same resistance on each rear wheel. Make the following adjustments:

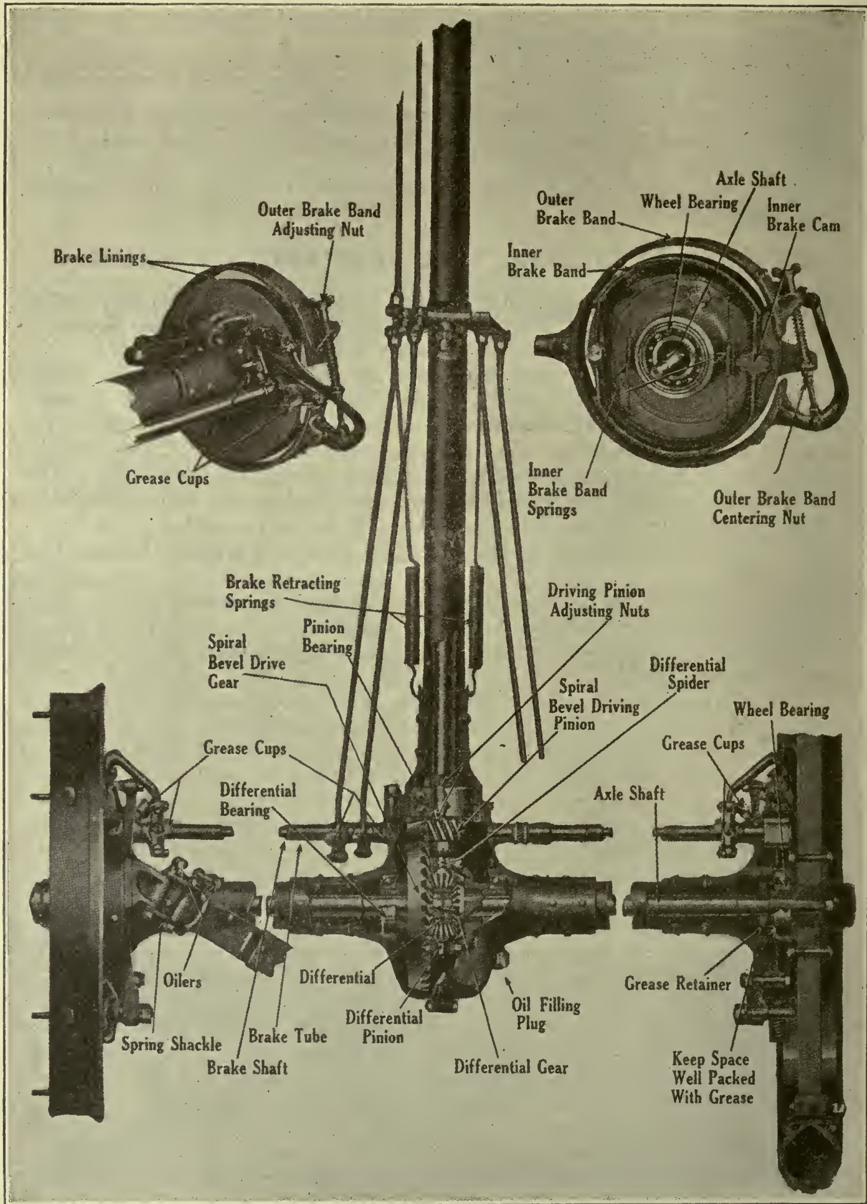
1. Make all adjustments for wear on the side pull rods connected to the cam shaft levers.
2. By removing the rear wheel the hand brake band can be set concentric with the brake drum by means of the set screw at the rear. The band should just clear the drum at this point.
3. The hand lever should be in the sixth notch from the front when the brakes are applied.

JOB 28. SPLIT HOUSING TYPE REAR AXLE OVERHAUL.

Certain of the lighter cars use a rear axle having the housing bolted together in the center rather than the one-piece construction. This construction is also found in a few of the heavier cars and some of the trucks.

1. Jack up the car and block up under the frame to hold all the weight free of the axle. If a hoist or crane is available, it should be used for this work.
2. Drop all brake rods, radius rods, spring clips, etc., which will in any manner prevent the axle being removed as a unit.
3. If the car cannot be raised high enough to permit the axle being pulled out to the rear, without the wheels striking the fenders, the wheels must be pulled and the housing dropped to the floor. (Refer to Job 30.)
4. Place the axle housing on the horses, or rack, and remove the propeller tube and shaft.
5. Remove the bolts holding the two half housings together.
6. Pull these away from the axle shaft assembly.
7. The next step is to open up and inspect the differential, noting carefully the method of assembly.
8. Very frequently the differential side gears are pressed onto the inner end of the axle shafts. To remove them it is necessary to press or drift the side gear downward a bit to remove the split retainer ring. This is usually at a point close to the inner end of the axle shaft. When the split ring is removed the side gear may be pressed or drifted off the axle shaft.
9. The parts should all receive careful inspection and those showing signs of wear should be replaced.
10. In reassembling the utmost care must be used to have all parts properly assembled. In some cases the gear adjustment is a fixed nature. That is, no provision is made for taking up wear. If the parts are otherwise in good condition, but an unwarranted amount of backlash is evident, it may be removed by the judicious use of shims. The most common method is to place a metal shim back of the thrust bearing which holds the bevel gear in contact with the pinion gear. A number of careful tests are necessary to insure the proper clearance of .005″ to .008″ between these gears.
11. Pack all parts with a medium cup grease or apply heavy oil to them so that lubrication is immediate when the car goes into service.
12. Reassemble under the car, being careful to have each and every part in proper position and properly secured with cotter keys and lock washers.
13. When reassembling the wheels on the axle care must be used to have the bearings properly adjusted and the brakes properly fitted.
14. It is a good plan to go over each part of the work as a matter of final inspection, and then again after a few days of service testing all nuts with the wrench to make certain they are snug. This refers to externally located parts.

Fig. 71. Overland Four Rear Axle and Brake Adjustments.



JOB 29. OVERHAULING REAR AXLES OF SINGLE PIECE HOUSING CONSTRUCTION.

In most cases of full floating, and in some cases of other axles, the housing is a pressed steel construction, so arranged that the differential assembly may be put in from the front or rear of the housing and the axle shafts from the ends.

In this construction it is seldom necessary to remove the axle from the car. The usual plan of overhaul in this case is to run the car, or lift it, onto blocks which will give sufficient room for the workman to get under it and at the inspection plate to the rear of the axle housing. After the car is in position, properly secured to prevent movement, proceed as follows:

1. Remove axle drive shafts. (Job 30.)
2. Remove inspection plate at center rear of housing. (Fig. 72.)

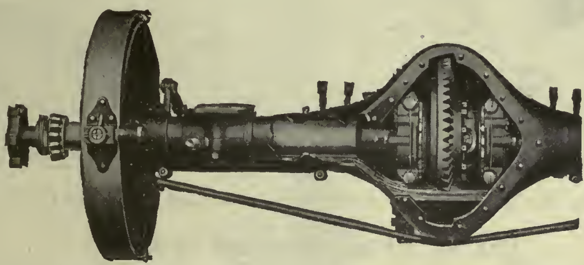


Fig. 72. Method of opening up axle for inspection and adjustment of the bevel gear.

3. If the differential is to be removed next release the four holding studs or nuts.
4. This permits of the caps being removed and the entire assembly being lifted out. Fig. 73 shows the assembly out but the caps and nuts in position. The same figure shows the notched adjusting rings by means of which the differential assembly is brought into proper relation to the pinion gear.

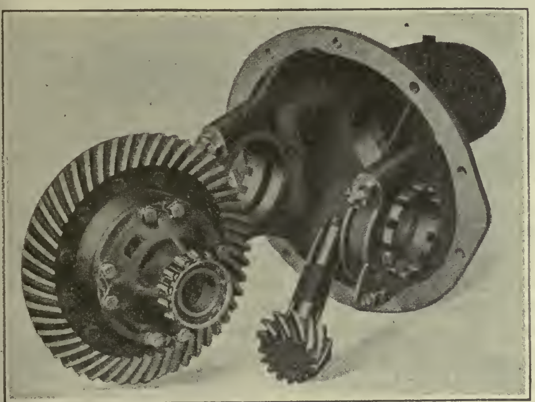


Fig. 73. Differential assembly and mounting.

5. The differential and bearings may now be taken apart and inspection and replacements made.
6. The pinion gear assembly should next be inspected and all worn parts replaced.
7. Replace the pinion gear assembly in position.
8. Replace the differential assembly in position.
9. Adjust these as suggested in Job 31.
10. Replace axle shafts.
11. Replace the inspection cover and fill with lubricant to the proper level.
12. Test. Make final inspection and adjustments.

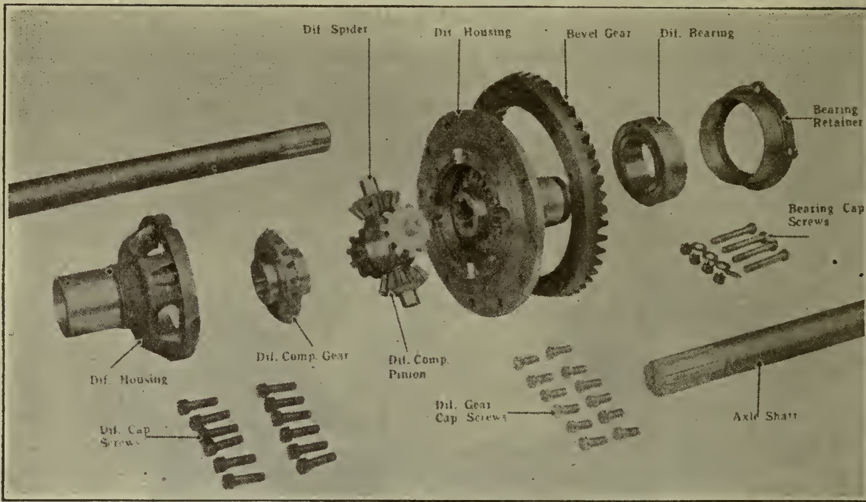


Fig. 74. Marmon Rear Axle Parts opened up for inspection.

JOB 30. PULLING REAR WHEELS.

The student should first study the external construction to note the type of axle being worked on and thus decide what is necessary to remove the wheel. Note the following points:

1. If the hub cap is a comparatively small one and the hub bolts have the rounded heads exposed the hub is of the socalled fixed type. The wheel is keyed to the shaft on a taper joint. To remove proceed as follows:

a. Jack up the axle to free the wheel.

b. With a hub wrench remove the hub cap.

c. Remove the cotter key and the castellated nut.

d. Attempt to pull the wheel by hand. Failing in this, put on a wheel puller which may be of the hub type which is screwed onto the threaded end of the hub and locked in position with a set screw, or it may be of the heavier type which is adjustable to fit over the center of the wheel back of the spokes or hub. When properly fitted, in either case the wheel is pulled by drawing on the center screw of the puller.

e. If the wheel proves stubborn it may be necessary to jar the set screw of the puller or the hub of the wheel to break its grip.

f. If no wheel puller is at hand, several scantlings or two-by-fours may be used to pry outward on the wheel, at the same time giving the end of the axle shaft a sharp blow with a bronze, lead or wood mallet.

g. Under no circumstances should the end of the shaft be driven on without proper pressure being applied at the rear of the wheel, nor should a steel faced hammer be used on the end of the shaft.

2. If the hub cap is small and the hub flange is held on by means of a number of hexagon nuts visible from the outside, proceed as follows:

a. Remove the hexagonal nuts, six or eight in number.

b. Gripping the hub cap and flange firmly, work it loose and pull off the flange when the shaft will be drawn with it.

c. Remove the locking device and then the nuts and bearing, after which the wheel may be removed by hand.

d. Be very careful to note the proper assembly of parts and preserve the earings free of all dirt and grit.

e. When replacing the bearings they should be cleaned and packed with ean cup grease.

3. When the hub cap is large the first step is to remove it, after which e axle drive shaft may be pulled by hand and the wheel removed as suggested nder 2.

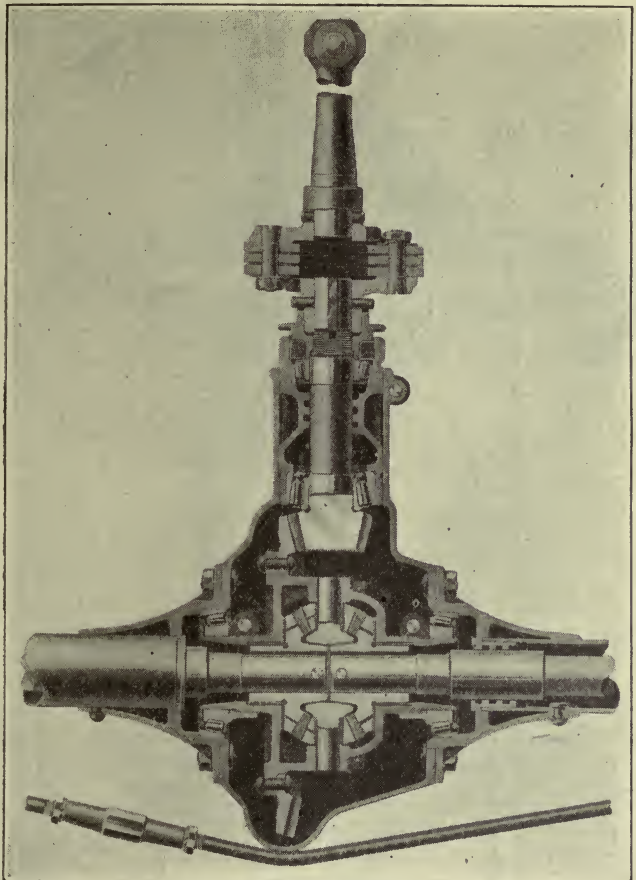


Fig. 75. Reo Rear Axle Adjustment.

JOB 31. ADJUSTING REAR AXLE BEVEL AND PINION GEARS.

For the most efficient operation as well as for quietness, it is very essential at the pinion and bevel be properly meshed. If they are set too close gether the axle will be noisy and growl or hum. Straight bevel gears are ore prone to be noisy than the spiral bevel. The clearance recommended for operly adjusted gears is from .005″ to .008″.

Fig. 76 shows the results of proper and improper methods of adjusting ese gears. A careful study of the chart is well worth the student's while.

There are three main reasons for rear axle adjustments. They, with the proper method of correcting same, are given below.

To Take Up Wear In Bearings:

1. Loosen the lock on the holding bolts. This is usually a wire, or cotter keys.

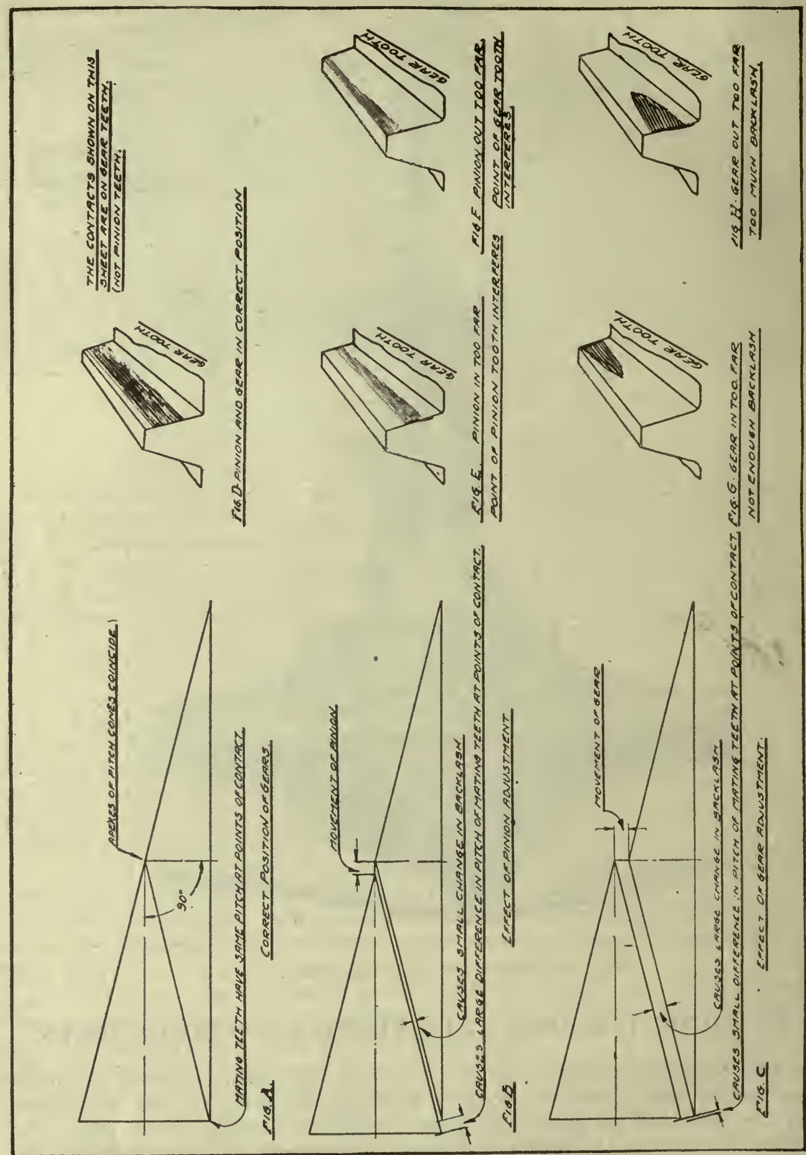


Fig. 76. Graphic representation of correct and incorrect methods of adjusting pinion and bevel gears. (Courtesy King Motor Car Co.)

2. Turn the adjusting rings until all perceptible looseness is removed, but the differential or pinion shaft is running free.
3. Set and lock.

To Take Out Excessive Backlash:

1. Release the locking devices on each side of the differential.
2. Turn both adjusting rings at the same time so as to allow the entire differential to be moved toward the pinion.
3. Allow the clearance recommended above.
4. Lock and secure parts.

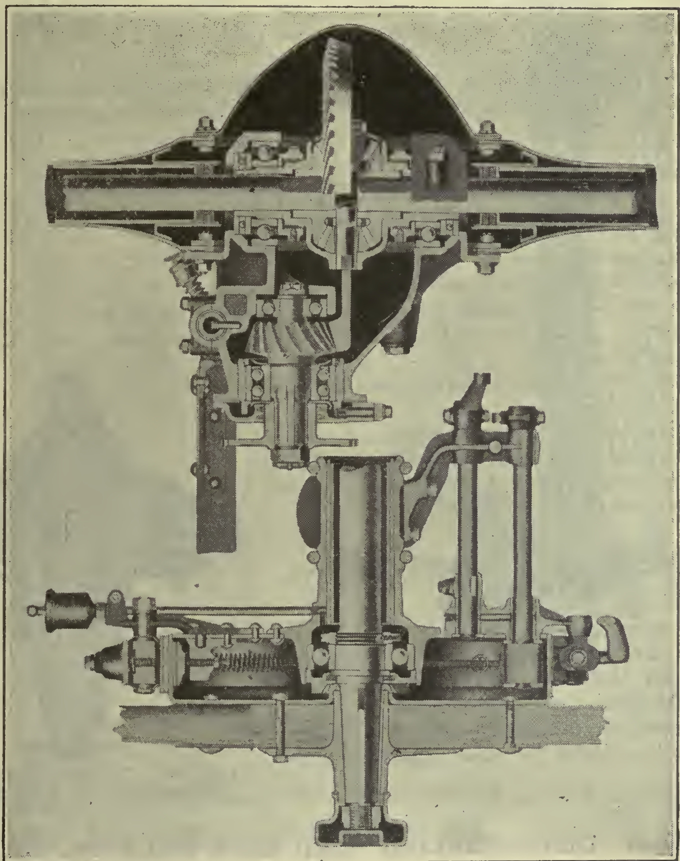


Fig. 77. Packard Rear Axle. Note method of adjusting pinion gear and bevel gear.

To Remove Noise and insure Proper Meshing of Teeth:

1. If the gears are new they should be set so that the rear edges of the teeth are even. This is effected through the adjustment of the pinion gear shaft forth and back.
2. Take up any play in the bearings.

3. Move the gear in, test for noise by running the engine.
4. Move gear outward, test again for noise.
5. Allow it to remain at the quietest point and secure by tightening and locking the holding screws.
6. Any excessive backlash must be removed by adjusting the differential.
7. When .005″ backlash is allowed a barely perceptible amount of motion is detected between the gears.
8. If it is desired to test the actual line of contact of the pinion on the bevel, which is the most certain method, the pinion must be coated with bearing blue and the marks left on the bevel gear noted. Or, the blue may be applied to the bevel and the results of driving it with the pinion noted by the marks left in the blue.
9. Ordinarily gears should be inspected each 5,000 to 10,000 miles, and adjusted if necessary.
10. An axle which grows suddenly noisy should be inspected and adjusted immediately. This will frequently effect a marked saving of expense for new parts.

JOB 32. REMOVE FORD REAR AXLE FROM CAR.

1. Jack up the car.
2. Remove hub caps.
3. Remove cotter keys and nuts.
4. Secure a wheel puller from the tool room, turn on the hub and lock with the screw. Turn the set screw onto the spindle and thus draw the wheel off the tapered spindle.
5. Remove 4 bolts at the universal ball cap.
6. Disconnect the brake rods.
7. Remove nuts from the spring perches.
8. Raise the frame of the car.
9. Remove the rear axle.

JOB 33. REMOVING UNIVERSAL FROM AXLE.

1. Remove two plugs from the top and bottom of the ball casting.
2. Turn the shaft until the pin comes opposite the hole.
3. Drive out the pin.
4. Pull or force the joint from the housing.

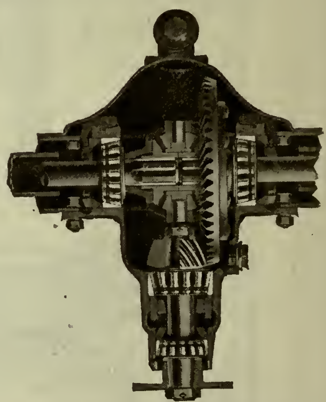


Fig. 78. Timken Bevel Gear Mounting in the Rear Axle.

JOB 34. DISASSEMBLING FORD REAR AXLE. Fig. 79.

1. Remove the radius rod nuts on the front end.
2. Remove the nuts from the studs holding the rear of the torque tube to the differential housing.
3. Remove differential housing bolts.
4. Working over the pan to catch the grease pull the parts apart.
5. Be very certain to place all nuts, bolts, etc., where they will be safely held for reassembly.
6. Clean the parts of grease.

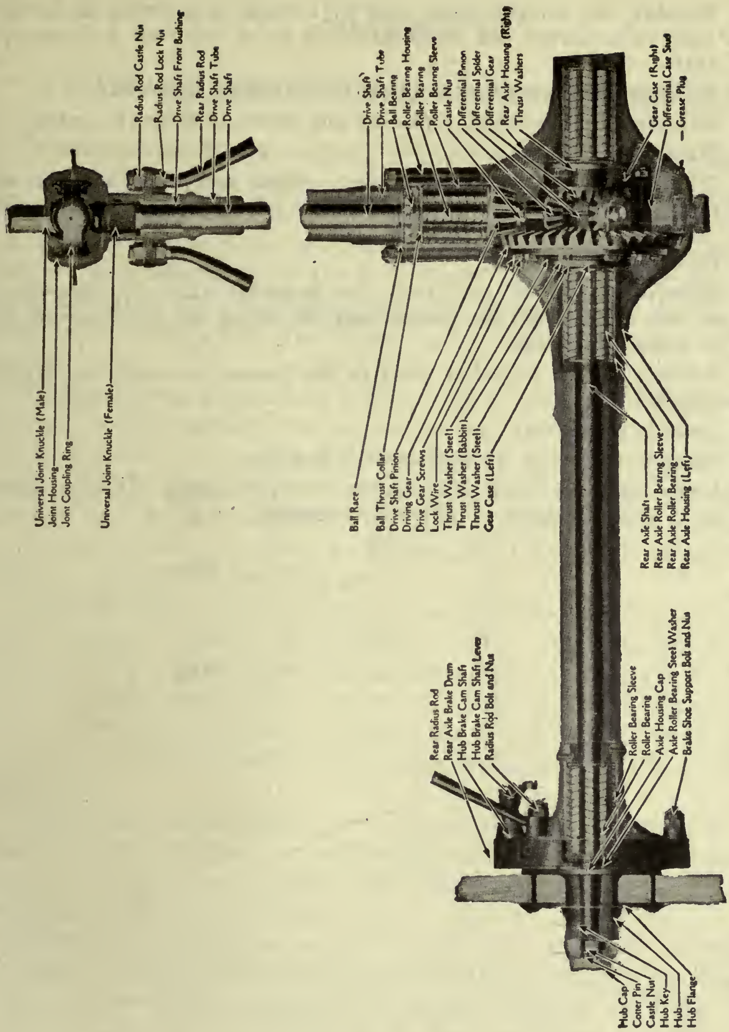


Fig. 79. Ford Rear Axle.

JOB 34-A. DISASSEMBLING FORD AXLE DIFFERENTIAL. INSPECTION AND REASSEMBLY. Fig. 79.

1. Remove all studs holding parts together.
2. Note as parts come apart how they are assembled.
3. Clean grease from them.
4. Study these differential gears to see how they function.
5. Which are the spider gears?
6. Which are compensating gears?
7. How are spider gears held on the spider? What work does the spider do, if any?

8. Remove one compensating gear by forcing or pressing down on the shaft far enough to permit the small split ring to be removed, and then press gear off shaft.

9. What prevents the shaft and gear from turning separately?

10. Reassemble differential, replacing any worn or defective parts.

11. Have them inspected.

12. Reassemble the rear axle housing. Great care must be used to see that the thrust bearings are properly assembled, otherwise the housing will be broken. Cup grease will hold them in place.

13. Have them inspected.

14. Remove the pinion gear from the propeller shaft by removing the cotter and nut, after which the pinion may be driven off, using a soft metal hammer or a block of wood.

15. Reassemble the propeller shaft in the torque tube and bolt it to the rear axle housing.

16. Have it inspected.

17. Place it under the car and fasten it in place.

18. Place on the wheels. Set up the nut quite snug. Inspect after 30 days to see if it is still tight. Tighten if necessary.

CHAPTER 4

CLUTCHES, TRANSMISSIONS AND UNIVERSALS.

Transmission Units.—Along with all other units of chassis design, the transmission has become standardized in the use of the sliding gear selective type. The most popular form is the four speed selective where three speeds forward and one reverse are provided. The selective progressive is in use to a slight extent, as are also the five speed selective and the planetary and friction disk drive. Of the progressive and friction disk little need be said as they are considered obsolete.

Progressive.—In the use of this type of gear box for the operator to obtain certain speeds, it is necessary that the gears must be meshed with and passed through other gears than those giving the desired speed. For instance, it is necessary to pass through second speed to reach high from a neutral position, and from high to intermediate, to neutral position, to low, and through it to reach reverse. This system is noisy and troublesome.

Friction Disk.—A large disk is mounted on the rear of the transmission shaft. Against its polished sides or steel surface a friction wheel is forced. The closer the friction wheel is brought to the center of the disk, the slower the speed. The farther from the center toward the edge, the faster or higher the speed. If the friction wheel is brought to center position it is in neutral and if past center reverse is obtained.

Progressive Selective.—In this case all gears or speeds may be selected at will, excepting only reverse, to reach which it is necessary to pass through low again. This provision is necessary as four speeds forward are provided.

Selective.—The selective is the nearest approach to the ideal. Any gear or speed may be selected at will by the driver, whether it be low, intermediate, reverse, or high. Reverse may be reached directly from high as is the need when stopping to turn. Intermediate, or high, may be entered immediately as is desirable in starting down a grade.

The need of change gears in the motor car, either passenger or truck, is a matter of fact. Even the multiple cylinder engine as represented by the twin types does not develop sufficient power at slow speeds to warrant attempting to do without them. The inherent nature of the gasoline engine is such that it does not develop its best power at speeds commensurate with starting on high gear. This is brought out in the chapter on engines.

Gear Ratio.—In figuring gear ratios it is best to remember that

in practically every case what is known as high gear is a direct drive through the gear box or transmission case. Although the gears are turning, the counter shaft is not carrying any load as it must at all other speeds. The countershaft is so designed as to be kept turning in order to facilitate speed changes and provide proper lubrication of gears and bearings.

In high gear the transmission shaft is locked together and turns

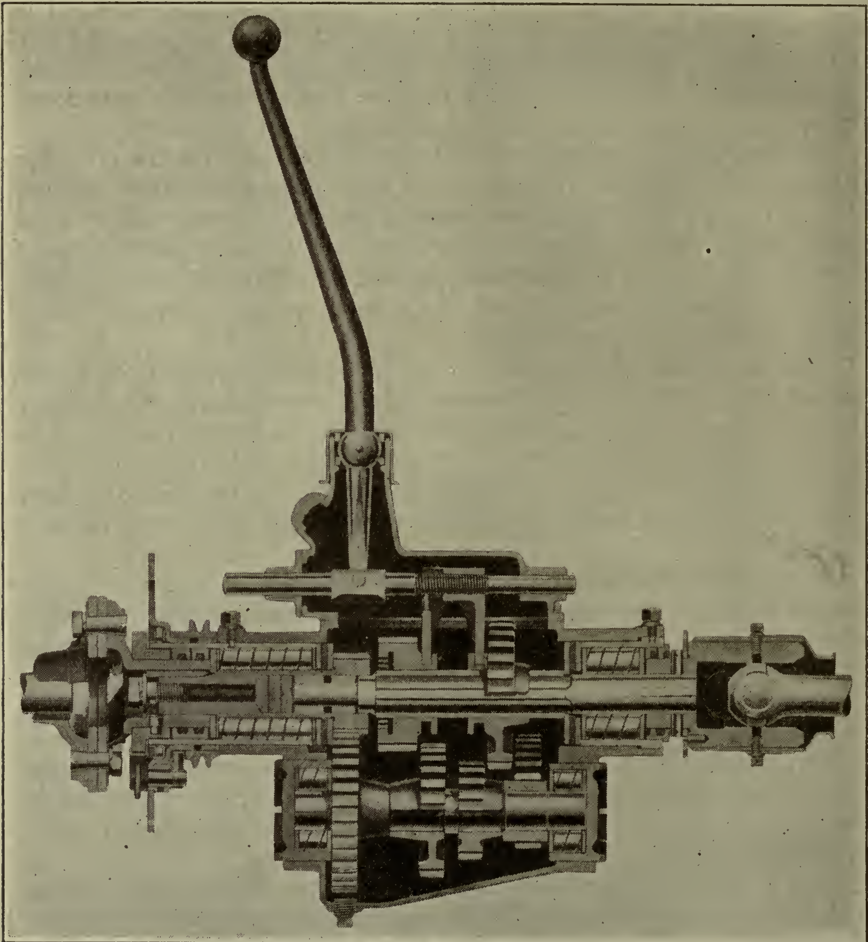


Fig. 80. Reo Transmission and Universals.

as one solid shaft. This arrangement allows the power to flow from the engine to the propellor shaft turn for turn or a 1 to 1 ratio. The entire gear reduction in high gear, between the engine and the rear road wheels, takes place in the ring and pinion gear ratio in the

rear axle. This varies somewhat, but about 4 to 1 may be considered an average.

When the control lever or gear shift lever is put into intermediate, neutral, low, or reverse, the transmission shaft is broken or divided into two independent parts. One end may turn at speeds different from the speed of the other end. This is possible since the shaft is made with a joint and bearing at a certain point which permits of the

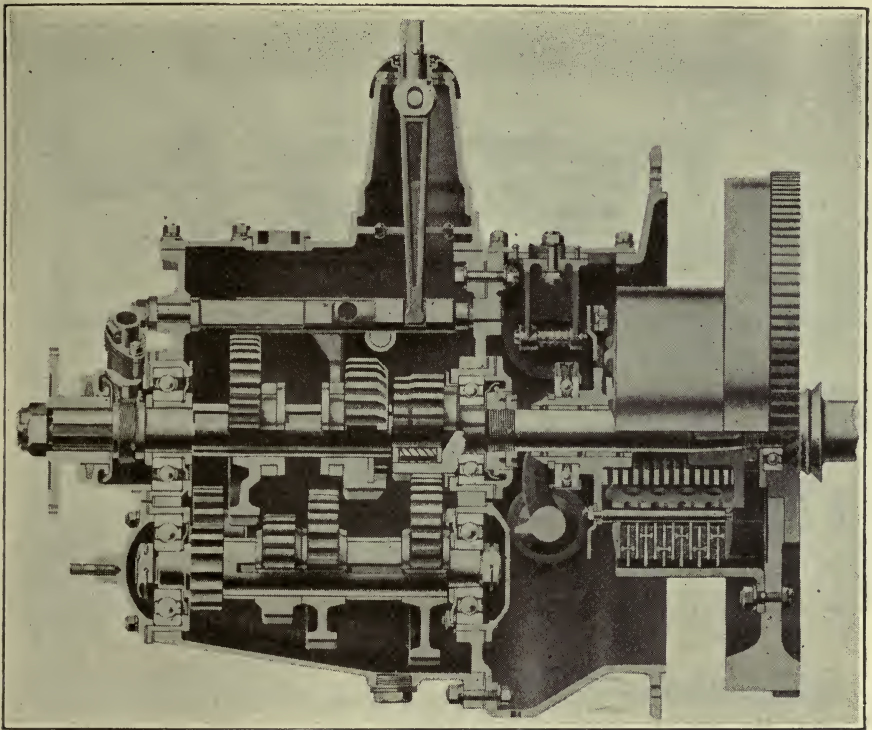


Fig. 81. Packard Passenger Car Clutch and Transmission.

shaft ends turning at different speeds except when on high gear. When in the second speed position the line of flow of power is interrupted and shunted out of a straight line through the idler gear, to the counter shaft, thence back to the transmission shaft, through the intermediate or second speed gear, and thence on to the propeller shaft and rear axle. This allows the power to be transmitted to the propeller shaft at a somewhat reduced speed, the exact reduction varying but being approximately 5 to 3. In this case then the engine to rear wheel reduction would be about 1 to 7. Shifting the control lever to low or first speed position gives a further reduction through the same shunt excepting that power now flows from the engine to

the transmission shaft, to the counter shaft, to the low speed gear, to the transmission shaft and the propeller shaft. This gives a gear reduction from the engine to the propeller shaft of approximately 3 to 1, with a consequent gear reduction from the engine to the road wheel of approximately 12 to 1. No set figures even for passenger cars can be given, as reverse or low may be as low as 20 to 1. Speed ratios from that figure up to 3 to 1 on high gear may be found.

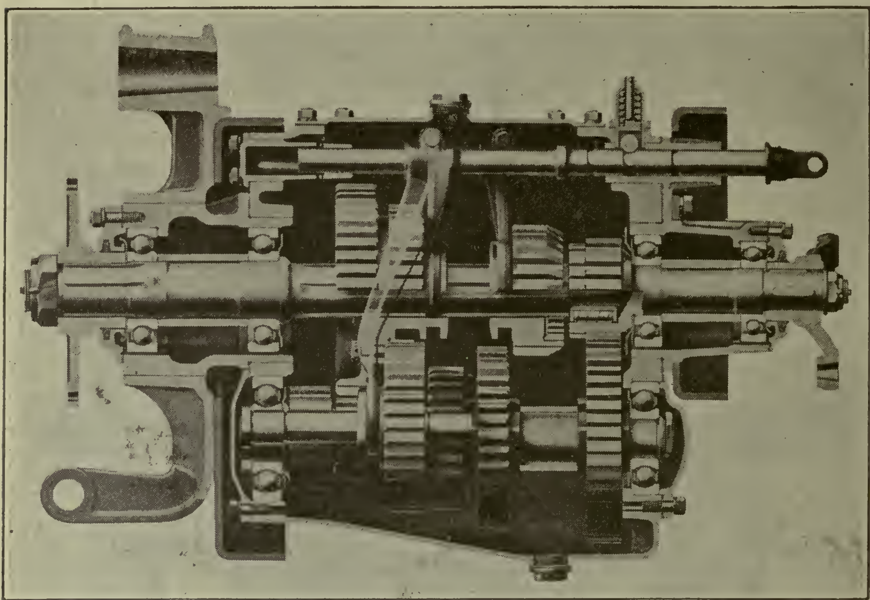


Fig. 82. Packard Truck Transmission.

Reverse Gear.—When the control lever is shifted into reverse position the sliding gear on the transmission shaft is meshed not with a gear on the counter shaft, but with an idler gear driven by the countershaft. The introduction of the additional gear gives the reverse direction of drive. The line of flow of power is from the engine to the transmission shaft, to the counter shaft, to the idler gear, to the reverse gear, to the transmission shaft, to the propeller shaft, rear axle and wheels.

Special Transmission Types.—Transmission gears and cases are built to carry varying loads. Trucks and tractors require heavier gears and cases. To obviate the danger of stripping gears in shifting, some trucks are equipped with transmissions in which the teeth of the gears are always in mesh. Speed changes are effected by means of sliding dogs which engage in dog clutches. The dogs having heavy jaws are less likely to be chipped, bent, or broken.

Transmission Troubles.—Transmission troubles most apt to occur are worn or broken teeth, worn or broken bearings and worn, bent, or broken shafts. A common fault which causes much inconvenience is to have the gear teeth worn a little tapering or sprung out of line due to having the load put on the teeth before they are fully meshed. This condition will cause the gears to pop out of mesh on a long hard pull. If taken when the trouble is first noticed it may be remedied by putting more pressure on the shift rod pawl spring.

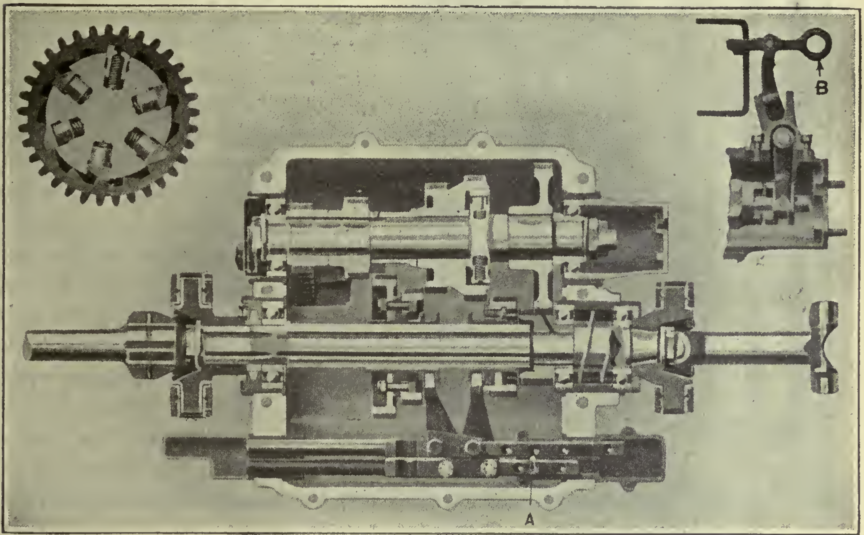


Fig. 83. Pierce Arrow Progressive Selective Transmission. Note the improved feature as shown in the over-running clutch which permits of shifting from high into second at high car speeds.

It is seldom, however, that a permanent repair is effected in this manner. For a permanent repair it is necessary to replace the worn gears and parts with new ones.

Planetary Type Transmission.—Here is used a mechanical principle rather difficult to grasp. Instead of a chain of gears as used in the selective type transmission where speeds are secured by shifting sliding gears, the planetary type uses a set of gears mounted on the flywheel which are always in mesh. In the case of the Ford car three stub shafts, studs or pinions, are mounted on the flywheel. The triple gears are mounted on these. A transmission shaft is mounted on the center of the flywheel. On this shaft is mounted a set of drums and three spur gears of varying sizes suitable to just mesh with the three sizes of the triple gears and the spaces between their inner edges around the transmission shaft.

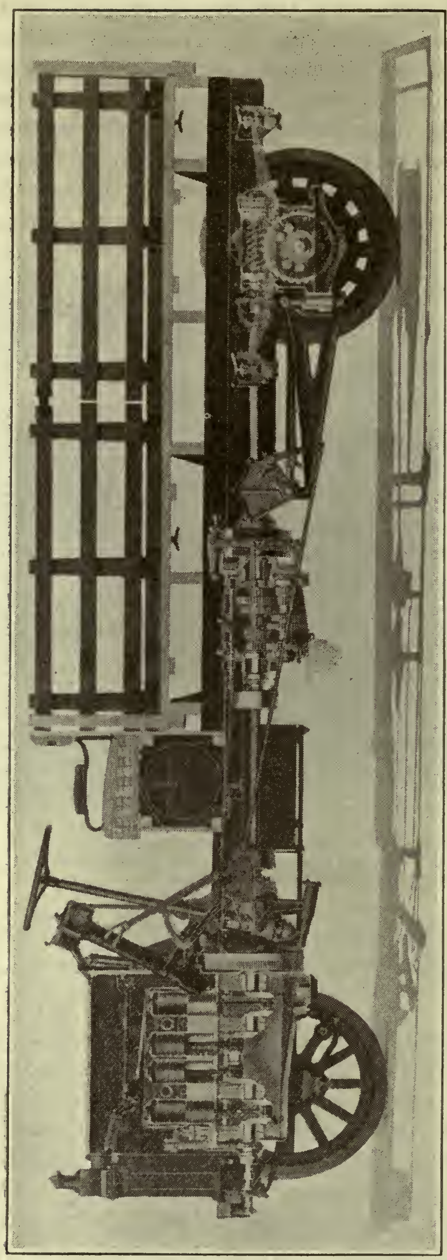


Fig. 84. Packard Truck showing position of Transmission Units.

High Speed. — Just as in other types the drive is straight through the transmission on high gear to the universal and propeller shaft. All drums and triple gears turn as one mass and part of the flywheel. On high gear the triple gears are stationary on their pinions, merely taking a free ride on the fly-wheel as it turns.

Slow Speed. — Pressing on the slow speed pedal stops the slow speed drum from turning. When it is stationary and the flywheel is turning, the triple gears are caused to turn on their pivots. This is because the slow speed drum shaft has a gear on the end of it which is in mesh with the triple gears on their center or largest part. As these triple gears revolve they in turn drive the driven gear which is mounted on the hollow shaft attached to the brake drum and driving plate. Their driving action is such that they cause the driven gear and parts to be driven backward while the flywheel turns forward. While the flywheel turns forward three revolutions, the driven gear and driving plate are backing up two revolutions. The driven gear being mounted on the flywheel has turned forward, however, one full turn over its original position. (These figures are only approximate.)

Reverse.—The same principle applies here, as it must be understood there can be no change of direction of drive from the triple gears since they are riveted together and turn as one at all times, and always in the same

direction. These gears turn in the same direction on their pivots as the flywheel and crankshaft turn on the engine bearings. In both cases the direction of rotation as viewed from the rear is counter clock-wise.

Pressing on the reverse pedal causes the reverse drum to be held while the triple gears travel around it. Since this gear doing the holding is larger than that part of the triple gear engaging it, each turn of the flywheel will give more than one turn of the triple gear. Four revolutions of the flywheel will give five turns of the triple gear which drives the driven gear backward at the same rate since these gears are of one size. In the case of reverse gear, while the flywheel travels forward four revolutions, the driven gear, driving plate and brake drum are driven backward five revolutions. This is one more backward for the propeller shaft then the flywheel gave forward. This gives a reverse gear ratio of approximately 4 to 1. This reduction is in the transmission. When considered in relation to the rear axle ratio of about 4 to 1 the gear ratio between engine and rear road wheel is about 16 to 1 on reverse. On low speed the ratio is about 11 to 1, on high speed about 4 to 1. (All figures given approximate.)

Planetary Principle Explained.—The term itself is derived from a fancied or real resemblance to the action of the planets as they travel around the sun. They have two motions, one as they travel in their orbits around the sun, the other a revolving motion as the earth turning on its axis. Since the principle is one of the most puzzling mechanical principles the student comes in contact with, several statements of problems are given.

Suppose you are aboard a railroad train one mile long. We will say you are at the front end which is at the depot. There are 90 cars in the train. While the train moves ahead one mile you walk toward the rear. At the end of the mile you have come to the sixty-first car from the engine or head of the train. The rear end of the train or the caboose is where the engine started. How far have you actually traveled with reference to the point at which you boarded the train or how far are you from the depot?

Now suppose the train is on a circular track, and that the caboose is in front of the engine, an endless train on an endless track. Repeat the problem. Again at the end of a mile travel for the train or engine you are 60 cars from the engine and 30 cars from the rear of the train, but now you can continue walking back while the train goes forward. Each mile run by the train finds you one-third of a mile farther from the depot. When the engine has traveled three miles you have traveled one mile from your starting point or once around the track.

Next suppose you start walking back as the engine starts for-

ward, and that you walk back 120 car lengths while the train and engine travel forward one mile which, as stated, is equal to 90 car lengths. How far from the depot, or your starting point, would you be and in which direction? Continuing this problem, while the train

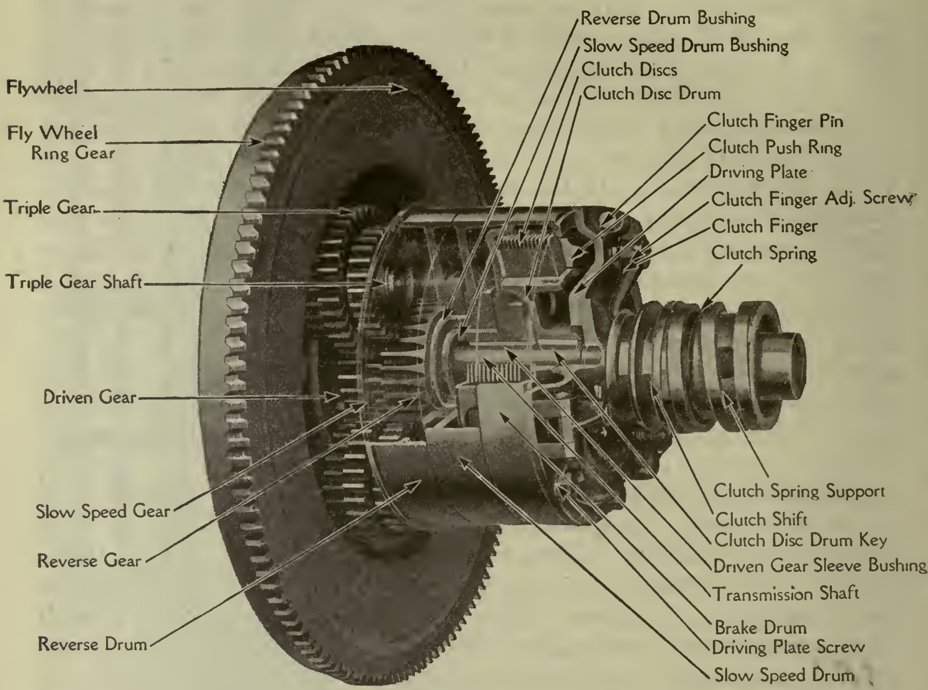


Fig. 85. Ford Planetary Transmission showing drums, gears, clutch and other parts.

goes forward three turns or miles you will have walked back four turns or miles, having actually traveled one mile from the depot, and that in a reverse direction to the direction the train is being run.

The Ford flywheel may be said to be the train of cars. The driven gear with its hollow shaft, brake drum and driving plate may be said to be the person.

Slow Speed.—On slow speed the triple gears are made to drive the driven gear and plate backward two turns to three forward of the flywheel. Actually it travels one turn ahead to three ahead of the flywheel.

Reverse.—On reverse speed the triple gears are made to drive the driven gear backward five turns to four turns ahead for the flywheel. Actually it now gains one turn backward to four ahead for the flywheel.

High Speed.—The clutch is not used at any time except when coming from neutral into high. On low and reverse the transmission

bands serve as friction clutches to apply the power evenly. The clutch on neutral is held out by the hand lever. When left in, which should be done with care, it locks the transmission shaft to the driving plate, by means of the friction plates, the action being identical to that of any other disk clutch. The main difference is that it is not used for low or reverse speeds.

JOB 35. REMOVING TRANSMISSION BANDS.

1. Take off the door on top of the transmission cover.
2. Turn the reverse adjustment nut to the end of the pedal shafts (same for the brake adjustment nut), then remove the slow speed adjusting screw.
3. Remove the bolts holding the transmission cover to the crank case and lift off the cover assembly.
4. Slip the band nearest the flywheel over the first of the triple gears, then turn the band around so that the opening is downward.
5. The band can now be removed by lifting it upward.
6. The operation is more easily accomplished if the three sets of triple gears are so placed that one is about ten degrees to the right of the center at the top.
7. Each band is removed by the same operation.
8. By reversing this operation the bands may be installed.
9. After being placed in their upright position on the drums, pass a cord around the ears of the three bands, holding them in the center so that when putting the transmission cover in place no trouble will be experienced in getting the pedal shafts to rest in the notches in the band ears.
10. The clutch release ring must be placed in the rear groove of the clutch shaft.
11. With the cover in place remove the cord which held the bands in place while the cover was being installed.

Caution. Be sure no small parts as a switch key, etc., are left where they may fall or be knocked into the transmission case; also tie a cord to all small tools being used to prevent loss.

JOB 36. RELINING FORD TRANSMISSION BANDS.

1. Carefully remove the old lining.
2. True up the metal band.
3. Place on the new lining and clamp it fast.
4. Place a block of wood in the vise, end grain up, shaped to conform to inside of band.
5. Hook the band over this.
6. Drive rivets through the lining into the wood. Use long and short rivets as required. It will be necessary to use a punch on some of the rivets to drive to the seat.
7. Spread rivets having the rivet head resting securely on metal. With a ball pein hammer drive the ends of the rivets a little below the surface of the lining. Unless extreme care is used the band will be driven out of true and require more time to straighten than the entire job should require.

JOB 37. ADJUSTING CLUTCH ON THE FORD CAR.

1. Remove the plate on the transmission cover under the boards at the driver's feet.
2. Take out the cotter key on the first clutch finger and give the set screw one-half to one complete turn to the right with a screw driver.

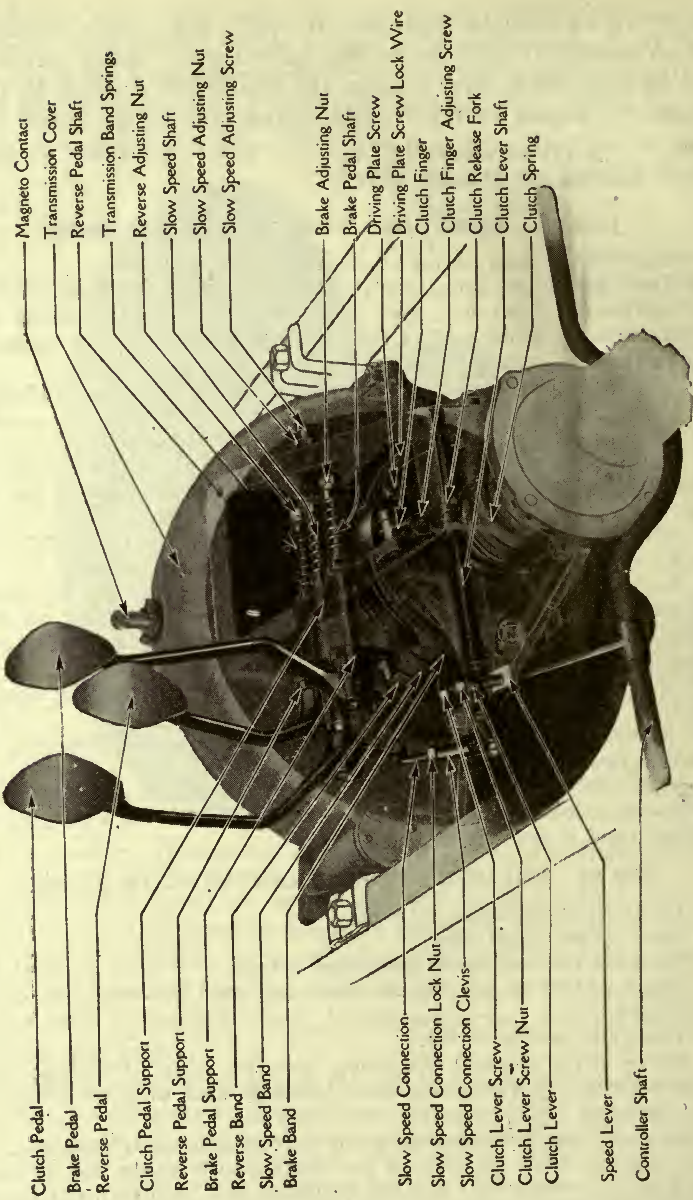


Fig. 86. Ford Transmission and Control Pedals.

3. Do the same to the other finger set screws.

4. Be sure to give each the same number of turns and don't forget to replace the cotter key.

5. After a considerable period of service the wear in the clutch may be

taken up by installing another pair of clutch discs rather than by turning the adjusting screws in too far.

Caution: Let us warn you against placing any small tools or objects over or in the transmission case without a good wire or cord attached to them. It is almost impossible to recover them without taking off the transmission cover.

JOB 38. OVERHAULING FORD TRANSMISSION.

1. Remove the engine. Job 56, Chapter 7.
2. Remove the transmission cover.
3. Remove the engine block with the transmission assembly.
4. Remove the bands.
5. Release the clutch finger adjusting pins.
6. Remove the driving plate studs.
7. Remove the clutch discs. Keep in order. Replace in exact former position.
8. Remove the disc drum stud.
9. Remove the disc drum with a special drum puller.
10. Pull the transmission.
11. Remove the driven gear from the back end of the brake drum using a press or special puller. Be careful not to break the drum.
12. Drums may now be taken apart after making certain that woodruff keys are removed from the brake drum shaft.
13. To renew clutch spring and collar: (a) Press the clutch spring support into the driving plate until the pin is exposed or in line with holes; (b) drive out the pin; (c) release the tension and the parts may be disassembled.
14. Examine triple gear rivets. Replace or tighten.
15. Inspect all bushings for wear and replace where needed.
16. Any necessary magneto work may be done at this time.
17. Clean all parts, especially clutch discs. Do not confuse these. Scrape with knife and scrub with kerosene.
18. Repairs having been made, parts may be reassembled, reversing operations.

JOB 39. STANDARD SELECTIVE TYPE TRANSMISSION OVERHAUL

It is not unusual for the transmission gears to be so worn as to make their replacement necessary. The main cause of this is the failure of the driver to understand the proper method of handling his car with reference to speed changes and clutch manipulation. Clashing and scraping of gears in shifting and allowing the load to come onto them when only partly in mesh will quickly damage the gears. The transmission shaft also is subject to unusual wear for the same reasons. In overhauling the transmission proceed as follows:

1. Inspect the job to see what is necessary to remove the transmission case as a unit. In many cases it is necessary to remove the rear axle. In others this is not necessary.
2. Take the case to the bench where the exterior is first cleaned.
3. Inspect the case to learn what is necessary to remove the bearings, shafts, and gear assemblies. Drain the oil.
4. Remove the gears and shafts.
5. Clean all parts free from grease and oil.
6. Inspect parts to see which must be replaced. Where gears are chipped, cracked, or worn beveled, it is necessary to replace them. Where the bearings and bushings are worn it is necessary to replace them. Inspect the bushings

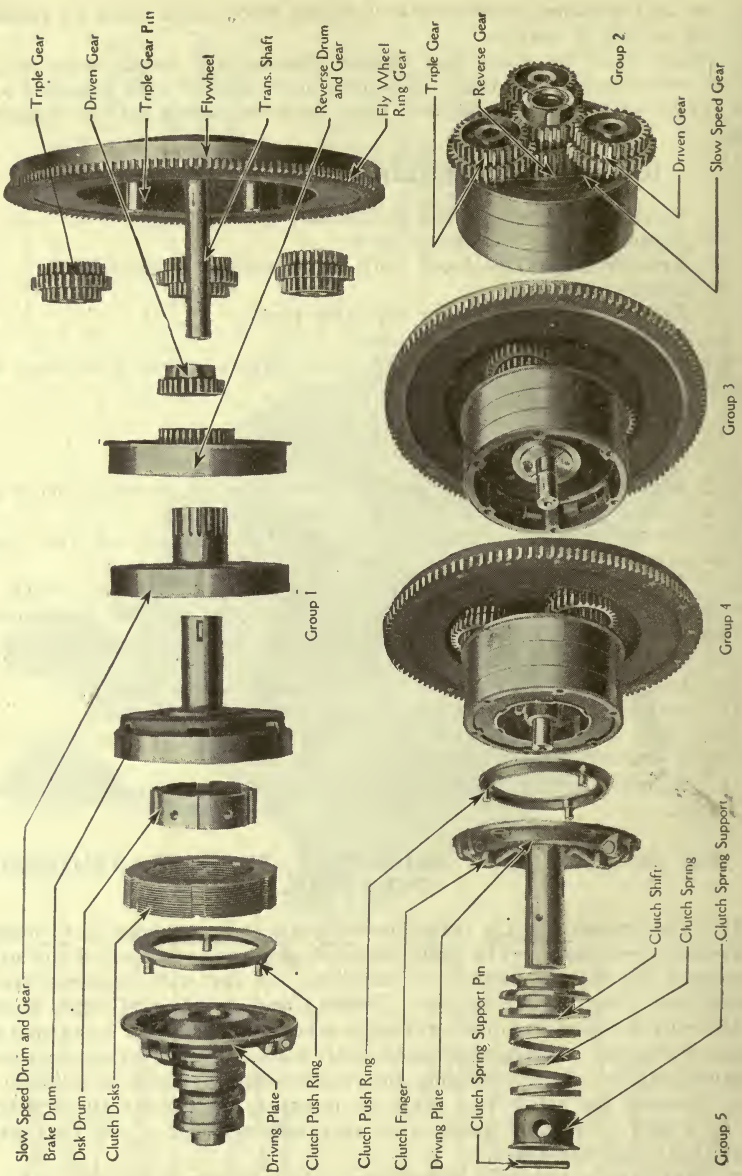


Fig. 87. Ford Transmission.

in the end of the clutch shaft or in the forward end of the transmission shaft. This is particularly subject to wear.

7. Where gears are riveted together or onto the shaft, it will be necessary to cut out the old rivets and replace them with new when the new gears are in position.

8. Note particularly the assembly so as to avoid any mistakes in reassembling the parts.

9. When the gears are all reassembled in the case, they should be shifted to see that the full width of the teeth is engaged when they are in mesh. This is very important.

10. It is sometimes possible to change the position of the gears by adjustments on the shifting forks.

11. See that the pawls and springs which lock the shifting fork rods in position are in good condition.

12. Where the clutch is a unit with the transmission go over it carefully. If the lining is dirty and greasy it should be cleaned with gasoline or kerosene. If badly worn it is economical to replace it at this time.

13. Replace the overhauled case in the car, making certain that all of the bolts and nuts are properly secured.

14. Fill to the level of the center of the counter shaft with the proper lubricant. (Job 40.)

15. Test.

JOB 40. STANDARD SELECTIVE TYPE TRANSMISSION CARE.

1. In the case of a new car it is well to drain away all old oil and flush out the transmission case after several hundreds of miles of service. The reason for this is the fact that at times in process of manufacture foreign substances are left in the transmission case and may work considerable damage. Also, the first few weeks of service will occasion more wear as the parts wear in than the succeeding thousands of miles will produce. All filings, chips and fragments of metal are carried by the oil to the bearings, unless the transmission is flushed and drained as suggested.

2. Refill the case with the oil recommended by the manufacturer. This is usually a heavy black molasses-like oil known variously as transmission oil, steam cylinder oil, and 600 W. In some instances a light graphite grease is used, and in other cases cup grease and gas engine cylinder oil are mixed to form a "dope" which is used for transmissions and rear axles.

3. Never fill a transmission case with a cup grease alone. It will all work out of the gears and bearings, clinging to the sides of the case where it does no good whatever.

4. After the first proper cleaning the case should be drained, flushed and properly refilled each 5,000 miles.

5. If the shift lever tends to pop out or jump out of second, or any other speed on a long, hard pull, it is likely that the gears are a bit worn or beveled. This trouble is sometimes due to the fact that the shift lever pawl spring needs strengthening. To do this, remove the old and replace with a new spring. A washer under the old spring will at times remedy the trouble.

CLUTCHES

The use of the clutch might be said to be similar to the hitching up and unhitching of a horse from a wagon. When the clutch is in, the power may be applied to move the load. When the clutch is out, power is no longer being transmitted through to the rear axle. Even and smooth application of power is possible when the clutch is in good condition and is eased in by the driver. A sudden leaving in of the clutch is like a horse starting too suddenly. Disaster is likely to be the result. In the case of the horse and wagon sudden starting results in broken harness and singletrees. The same equipment will move equal and larger loads for many years if the horse can be

taught to take hold on the load slowly and steadily. The horse will also last longer. With the motor car sudden dropping in of the clutch will spin the wheels, cut tires, stall motors, break transmission

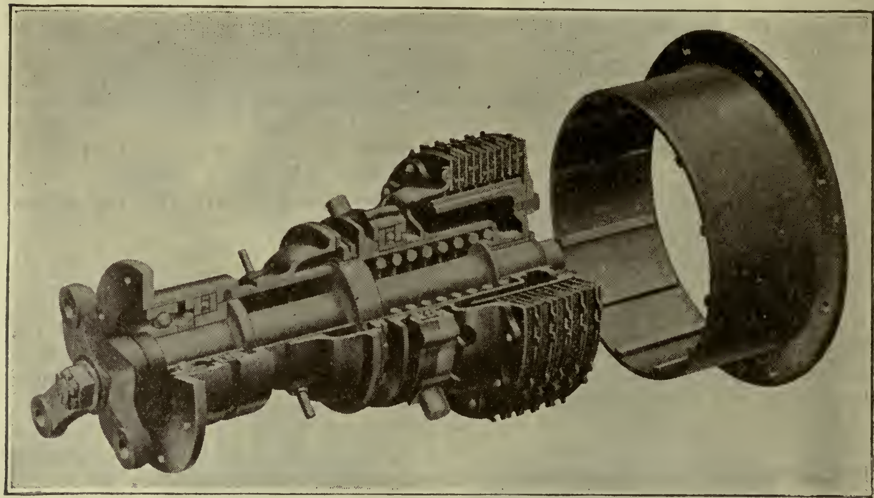


Fig. 88. Heavy Duty Clutch of the Multiple Disc Type.

shafts and gears, break rear axle gears and shafts, and generally bring rack and ruin to all power transmission parts.

An even steady application of power through easing in of the clutch will result in a saving of all parts used in the transmission of power as well as tires. Careful handling of the clutch will do more than any one other thing the driver is able to do to prolong the life

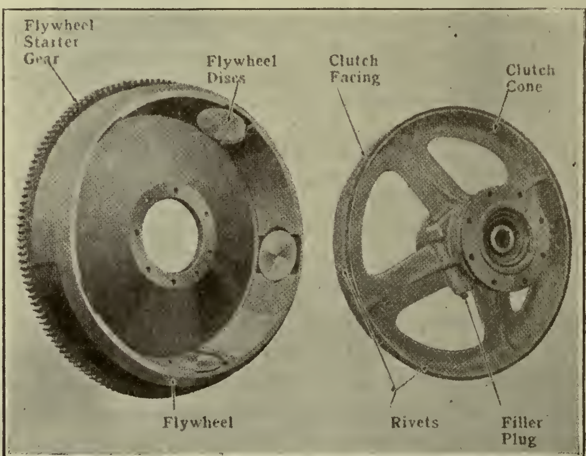


Fig. 89. Marmon Cone Clutch and Fly Wheel.

of the car. Careless handling of the clutch in the shifting of gears and general use of it will take many years from the normal life of the chassis.

Types of Clutches.—Plate, multiple disk and cone clutches are those in general use. These may be designed to operate with or without oil. If without, they are said to be dry clutches, if running in a bath of oil they are said to be wet clutches. The dry clutch

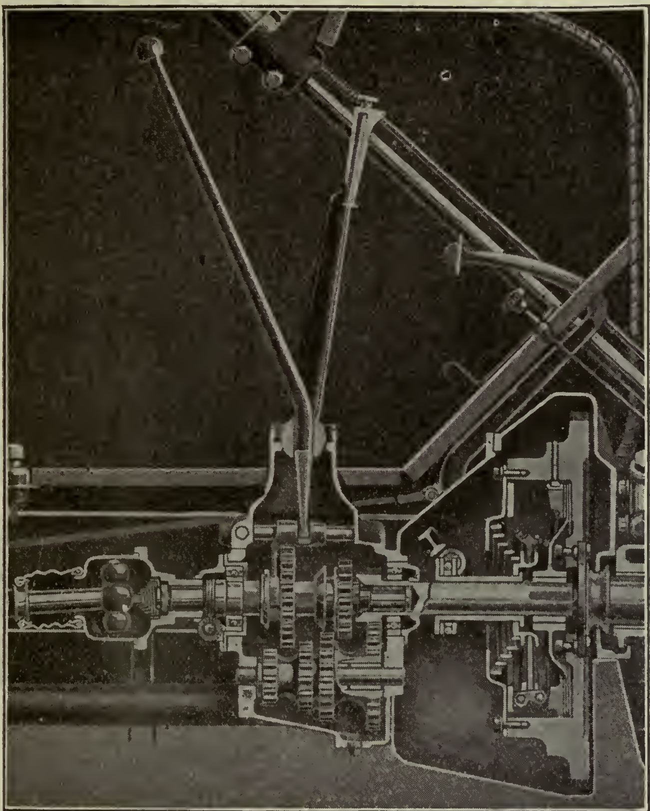


Fig. 90. Allen Transmission and Plate Clutch

holds a larger degree of favor. In every clutch the principle of operation is to bring some material possessing great friction qualities into contact with a polished steel surface. Pressure of the clutch springs holds it against the steel surface and pressure on the clutch pedal releases this first pressure by compressing the clutch springs. The great pressure induced in the clutch spring when it is compressed by the clutch pedal and related parts will immediately throw the clutch back in when the foot pedal is released. Because of the strength of the clutch spring it is sometimes impossible to leave the clutch in

without having it grab. It also makes it very hard to teach the novice how to handle the clutch as he is apt to think that all he needs to do is to release all pressure from the pedal to have it engage properly. Releasing or throwing out the clutch stores in the clutch spring the power used in throwing the clutch in. This power must be released very gradually in order to insure proper starting of the car.

Cone Clutches.—The cone clutch is usually fitted into the rim of the flywheel. The flywheel has the rim turned or bored out on a slight angle as may be noted in the illustrations. This insures a wedg-

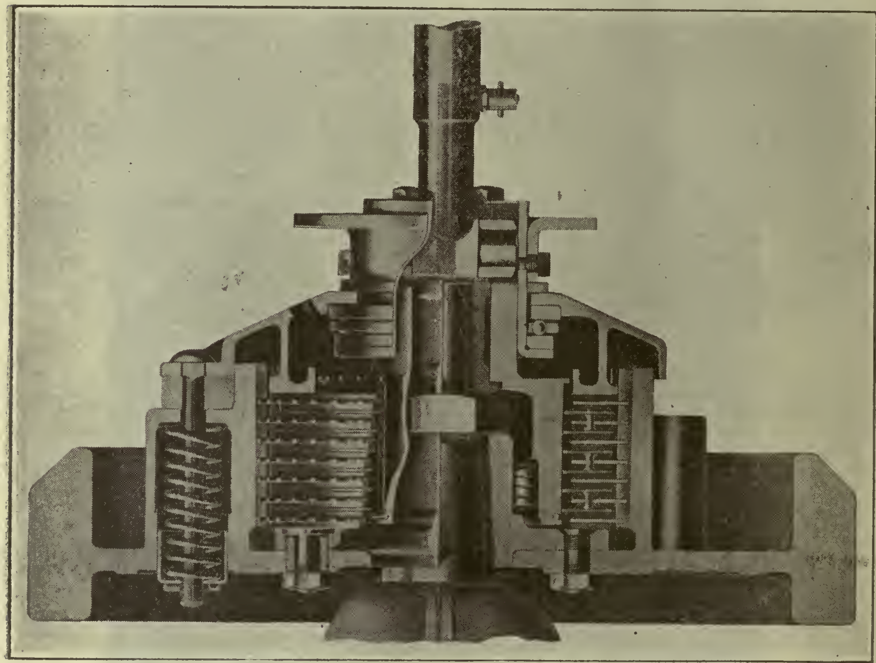


Fig. 91. Reo Passenger Car Multiple Disk Clutch.

ing action as the clutch comes in, and a clearing action as the clutch is thrown out. The clutch is controlled by means of the left foot pedal as are all other types. The spring action here may be of several types. Either one large spring is mounted over the clutch shaft, or the clutch shaft is provided with a collar and web through which bolts are run allowing three or more springs to be used on the back of the flywheel to give the proper tension for holding the clutch in or properly engaged. Either style may or may not be adjustable for spring tension.

Plate Clutch.—The plate clutch, of which the Borg and Beck is the most popular type, is one in which a single plate or heavy disk

is gripped between two rings of friction material. One of these rings is fastened to the face of the flywheel, and the other to a thrust ring mounted on and driven by the flywheel. When the

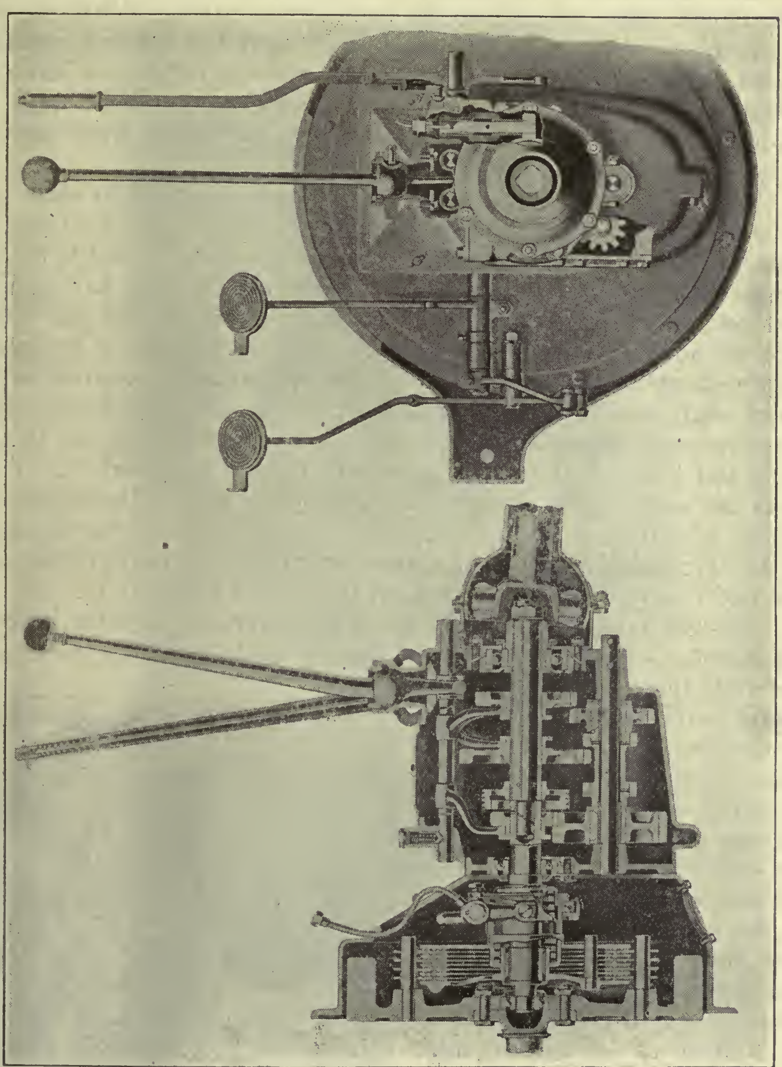


Fig. 92. Dodge Plate Clutch and Transmission.

clutch is out, the single driving plate is left free to stand still beween these two friction lined surfaces. The load is taken by this plate as the clutch is left in, and the speed of the plate is gradually picked up or brought up to a speed corresponding to that of the engine fly-

wheel. At this point it is gripped and held. Through it the power then flows or is transmitted to the transmission propellor shaft and rear axle.

Disk Clutches.—The main point of difference in the wet and dry disk clutch may be said to be one of operation. With the dry clutch the driver must be depended on to leave the clutch in gradually and easily. With the wet clutch the oil may be said to make the operation semi-automatic, as oil left between the plates is forced out gradually, until when the oil is practically all forced from between the plates or disks the clutch is holding fully.

The manner of transmitting the power is identical in each case. In most designs a set of pins is mounted on the flywheel and on these pins is mounted one set of disks. When the flywheel is turning the plates mounted on it turn with it, although they are free to move back and forth on the pins as the clutch is thrown or left in. These disks do not touch the clutch shaft but have an opening at the center large enough to clear it readily. When disks are mounted on the clutch shaft, which is usually the front half of the transmission shaft, they are made and mounted in such manner that they are free to slide forth and back on the shaft, but must always turn with it. These disks are made small enough to permit their turning inside the set of pins mounted on the flywheel and carrying the other set of disks. Of the two sets every other disk is mounted on the flywheel pins, and every other one is mounted on the clutch shaft.

For the sake of clearness, suppose that there are nine disks to the clutch. Five of these would be mounted on the flywheel pins, and it is likely that these five would carry the rings of friction material. Four of the disks without lining would be mounted on the clutch shaft, turning only with it. Pushing the clutch pedal down releases the pressure holding the plates or disks together, thus permitting them to separate. With the pressure off, the disks on the clutch shaft gradually come to a stop. To hasten this action most designs incorporate a clutch brake which comes into action as the clutch pedal reaches its limit of travel. With the foot pedal down and the plates separated, the clutch is said to be out. Releasing the

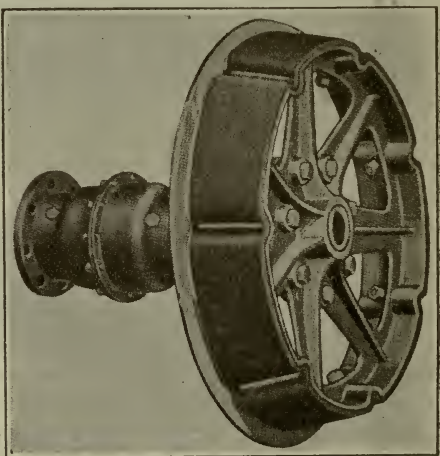


Fig. 93. Kelly Springfield Cone Clutch.

clutch pedal permits the clutch spring to throw the plates back together at which position the clutch is said to be in.

As stated above, the set of plates carried by the flywheel are the usual ones to receive the clutch lining, as weight is not detrimental in this case as it is in the case of the set on the clutch shaft which must be stopped quickly.

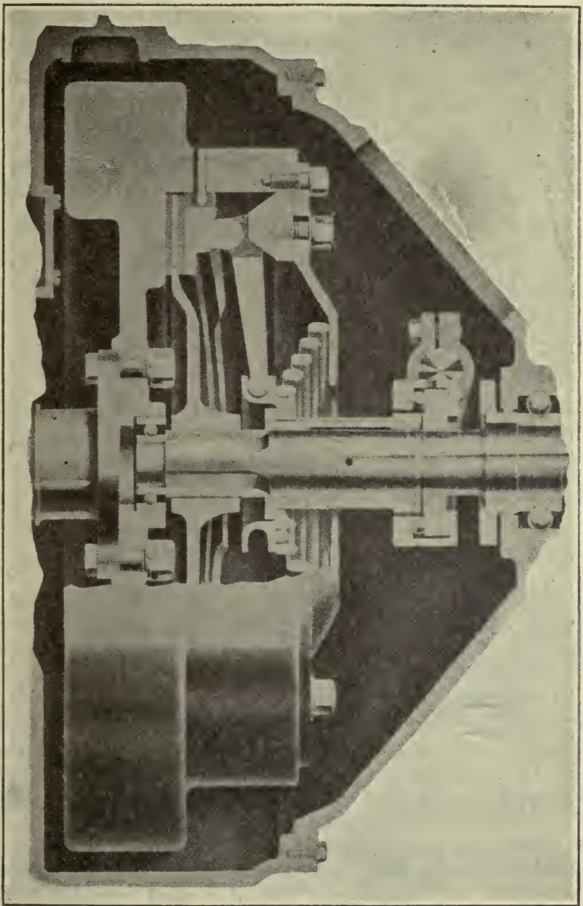


Fig. 94. Borg and Beck Dry Plate Clutch.

Grease and Oil Soaked Clutches.—Occasionally, especially the exposed cone type become soaked with oil and grease, and slipping of the clutch results. This surplus oil should be removed and the clutch lining treated with neatsfoot oil.

Neatsfoot Oil.—This is the standard remedy for clutch leathers and linings. Properly used, it makes the leather soft and pliable

bringing out its natural friction qualities, thus giving the clutch a chance to hold onto the polished steel. Automotive accessory supply houses carry a line of neatsfoot oil especially prepared for clutch linings. It may also be secured from drug stores. Castor oil is sometimes used as a substitute.

Grabbing Clutch.—This condition is due to a dry hard lining. Either leather or fabricated linings are subject. An application of neatsfoot oil will make the lining soft and pliable, after which it will respond to careful handling by the driver without grabbing.

Slipping Clutch.—Just the opposite of grabbing is the case here. The remedy is the same. The lining should be restored to its original state by the application of neatsfoot oil. At times the wear on the lining has decreased the normal spring tension or the springs themselves may have become weak. In this case it is advisable to increase the spring tension, or to replace the old springs with new ones. Sometimes a spring will become broken. This fact cannot always be detected as the springs are frequently entirely enclosed. To inspect the spring it may be necessary to dismantle the clutch.

Wet Clutches.—A clutch made to run or to operate in oil may need to have the oil drained, the parts flushed with kerosene and the case refilled with the grade of oil recommended by the manufacturer of the car in question. The wet clutches may be of any type, but the wet disk is most popular. The wet cone clutch is also in use. If the oil is not of the proper consistency, slipping may result.

JOB 41. CLEANING AND OILING AN EXPOSED CONE CLUTCH.

In cases where the clutch is of the cone type, the dirt and grease accumulating on it will result in clutch trouble. To remove it the floor boards are removed and a stiff paint brush and kerosene are used to wash the oil and dirt away from the parts. When the exterior parts are clean the brush is next cleaned and a fresh supply of kerosene secured. Prop the clutch lever with a short stick to hold it in "out position". Wash out the grease from the clutch lining and the face or seat on the flywheel. Apply a coat of neatsfoot oil.

JOB 42. APPLYING A NEW LINING TO A CONE TYPE CLUTCH.

When the clutch facing, which is usually leather, is worn or burned to a point where it will no longer hold, it is necessary to reline or recover the cone. Certain fabrics similar to brake lining are also used for clutch facings. The methods of replacing old with new are similar no matter which material is used. It is a very excellent plan to use the type of facing recommended by the car manufacturer since he has doubtless experimented with a number of styles and knows what is best for his product.

1. In most cases it is necessary to drop the transmission unless the transmission happens to be built as a unit with the rear axle, in which case the rear axle may have to be pulled.
2. Make such further arrangements and adjustments as are necessary to get at the cone.
3. Remove the old lining being careful not to harm the cone surface.

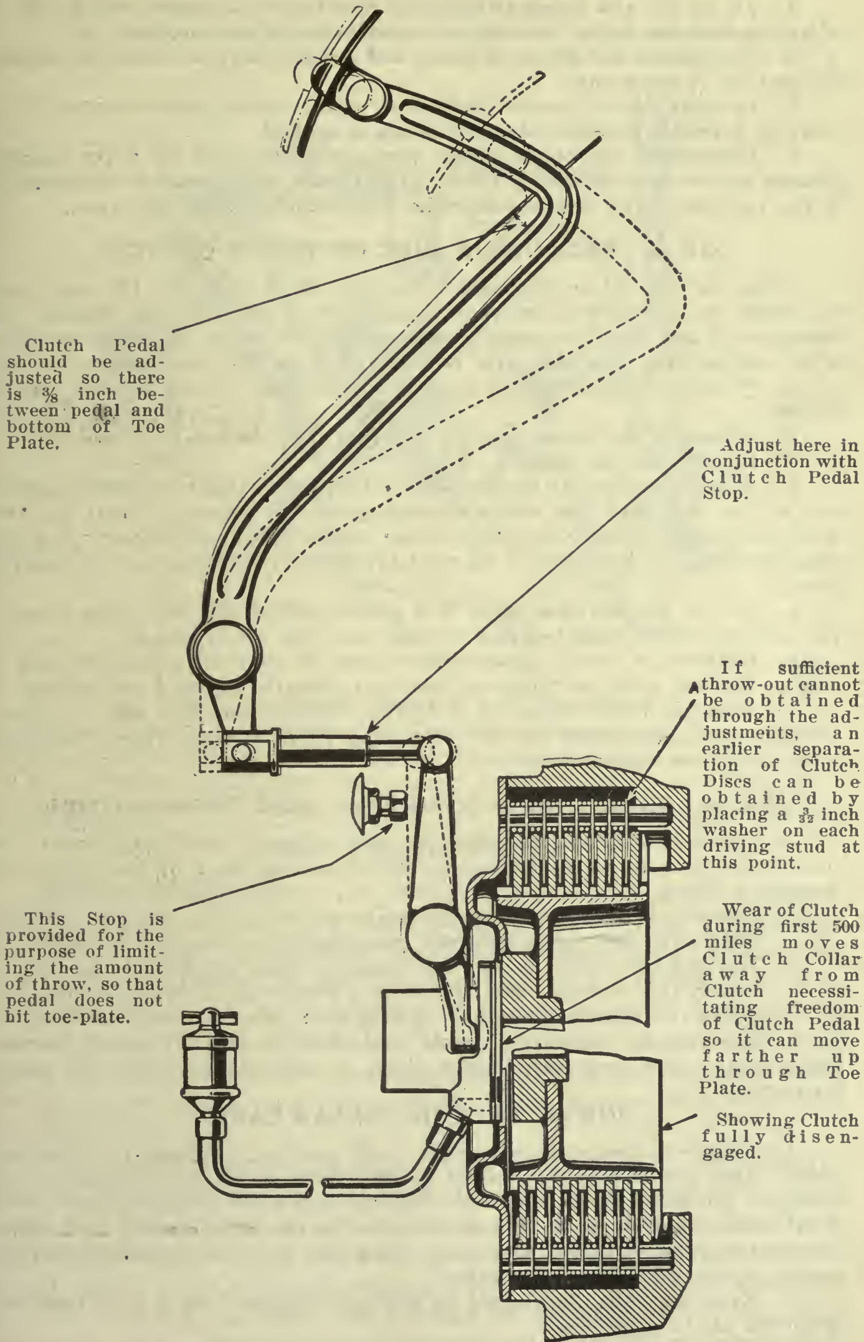


Fig. 95. Hudson Clutch Pedal Throw Out Adjustment.

4. Fit on the new lining stretching it evenly. If a leather cone lining, it is well to soak the leather in water or neatsfoot oil before applying.

5. Countersink for the rivet heads and see that they are sunk well under the surface of the lining.

6. In cases where flywheel disks with spring arrangement are used, they must be in proper position when the facing is applied.

7. Reassemble the clutch, being very careful to have all parts cleaned, greased and in their proper position. The clutch spring may be compressed in the vise and wired together to make its assembly somewhat easier.

JOB 43. RELINING A DISK OR PLATE CLUTCH.

When the take-up on this type of clutch is all used so that the clutch can no longer be adjusted to prevent slipping, it is necessary to remove the transmission and clutch in order to dismantle it and reline the disks or plates with new facings. Use the style recommended by the manufacturer.

1. Remove the transmission and clutch assembly, or such parts as may be necessary.

2. Dismantle the clutch parts, preserving them in order.

3. Remove the old lining.

4. Replace the old with the new lining or facings. These are usually applied two to one disk with the rivets through both. In selecting rivets for this work make certain that they are just the proper length to properly head up when the other, or head end of the rivet, is properly countersunk in the opposite lining.

5. Set the countersunk head on a punch held in the vise while riveting the end over with a small ball pein hammer and rivet set or punch.

6. Reassemble clutch using extreme care to have all parts put back in order. See that parts are clean and bearings properly adjusted and lubricated.

7. After the new facings are in service a short time, they are very likely to need some adjustment for the first wear which is more rapid than later when they have been worn in.

JOB 44. ADJUSTING A BORG AND BECK TYPE CLUTCH.

In Figure 96 is shown the Allen car with indicated clutch adjustment. In some cases it is necessary to remove the inspection plate of the clutch and flywheel housing.

1. Remove the inspection plate if such is used.

2. Turn over the engine until the two adjusting screws are located.

3. Holding the clutch in the "out" position these are both loosened.

4. Gently tap or move these screws in a clock-wise direction from ¼" to ½". Tighten the adjusting screws. A very little movement is sufficient.

5. Replace the inspection cover and floor boards. Test. If further adjustments seem necessary make them in accordance with the above instructions.

JOB 45. CLUTCH COLLAR CARE.

The clutch is always thrown to the "out" position by pressure on the foot pedal. This pressure is transmitted to the clutch collar and through to the springs. The collar is standing still while the clutch and springs are revolving. A tremenduous pressure is thrown onto the clutch collar bearing, and unless this bearing receives proper lubrication the collar will become worn and make trouble when gears are to be shifted.

1. Keep the collar lubricated by giving the grease cup a turn each day when the car is in service.

2. Make certain the grease reaches the collar or bearing.

3. The bearings are either bronze or ball thrust.
4. Do not allow the weight of the foot to rest on the clutch pedal while the car is in service except when the clutch is actually in service. To do so

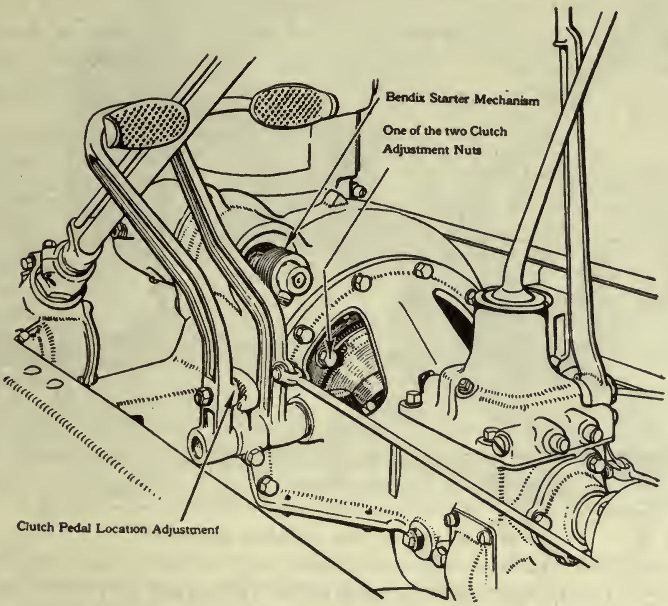


Fig 96. Adjusting Borg and Beck Type Clutch.

is likely to start the clutch slipping, or by placing a constant strain on the collar cause it to be burned out. Either of the above conditions is serious.
5. A burned clutch collar acts just as a clutch brake, and in bad cases causes the clutch to stop so quickly that it is impossible to shift gears properly.

UNIVERSAL JOINTS

Mechanical Principle.—The mechanical principle of the universal joint is simple, although in its application some very complicated problems are met. A universal joint may be said to be the coupling of two shafts endwise so that the one may give a rotary motion to the other when forming an angle to it, and at the same time may be moved freely in all directions. Many elaborate and complicated forms have been worked out and designed to fit some particular need, but all forms reduce in principle to the plain gimbal joint shown in Fig. 100.

To a casual observer the need for universal joints in the propeller shaft of an automobile is not always present. At first glance it would seem that the propeller shaft might be run in a straight line from the transmission case to the rear axle without the use of any universal joints, but a moment's thought will show how impossible this is. The absolute necessity for a universal arises from the fact that the engine is mounted on a rigid frame and therefore moves up and

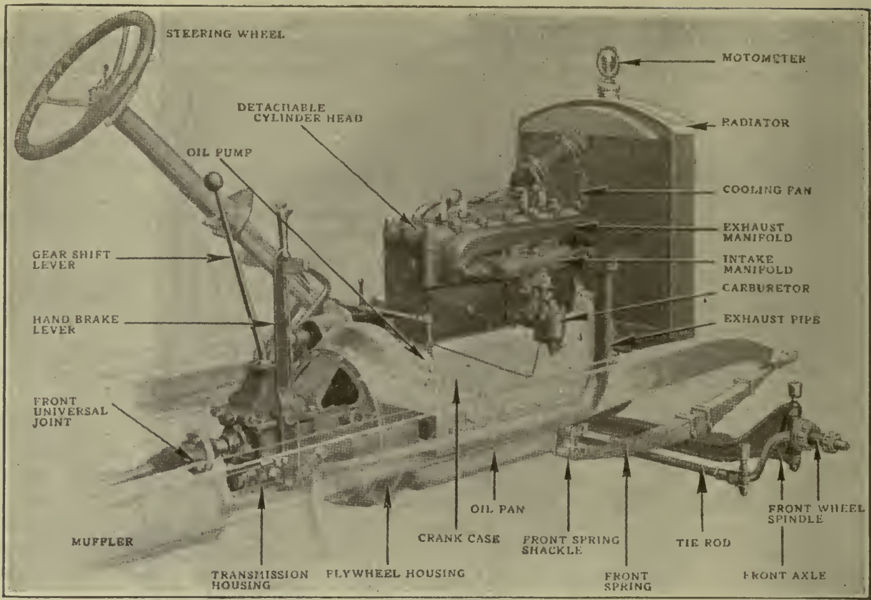


Fig. 97. Front end of Allen Chassis.

down with the springs while the rear axle follows the contour of the road. Or, the result may be said to be the same as if the frame were still and the rear axle moving up and down. Aside from the movements described above there is always present a slight weaving of the frame which adds to the necessity of the universal.

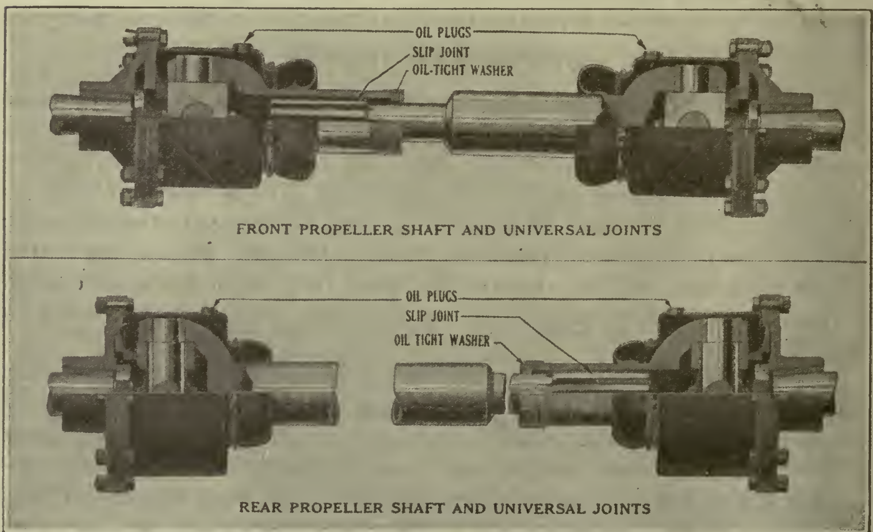


Fig. 98. Propeller Shafts and Universal Joints for Truck Use. (Standardized Military Model Class B.)

In some machines the transmission is placed at a distance from the clutch and is not attached to the crank case. This is known as mounting the transmission admidship. With this construction it is necessary to provide universals between the engine and transmission to care for the weaving of the frame and the likelihood of the two units not being mounted in absolute alignment.

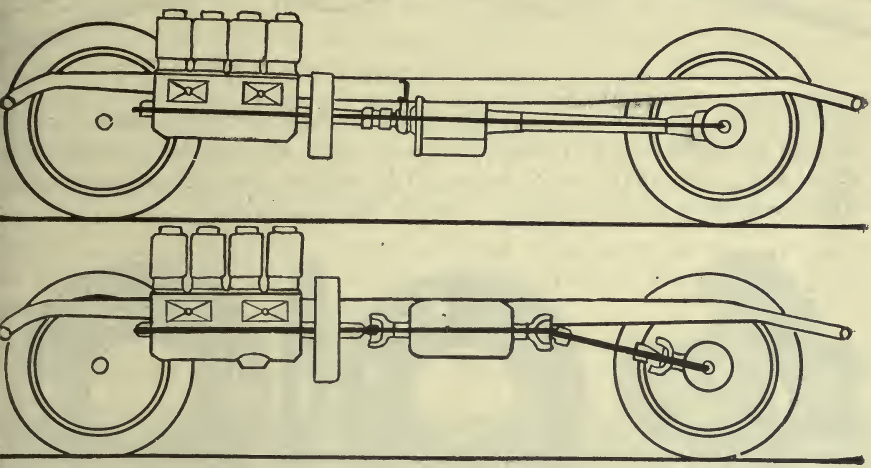


Fig. 99. Illustrating need of universals and contrasting straight line and angular drive.

Angle of Drive.—In Fig. 99 is shown what is meant by straight line and angular drive as applied to the automobile chassis. The problems which must be solved in designing a universal are evident when considering the lower chassis. In the ordinary form of the metal universal the ends of the shaft are forked and fitted over a central or connecting piece in the shape of a cross, which construction allows each shaft to be moved freely in any direction. The amount of movement is held within certain limits. A rotary motion of one is readily transmitted to the other without much loss of power unless the angle of drive becomes too great. It is evident that the nearer to a straight drive the less the friction in the universals and the greater efficiency obtained. The nearest approach to the ideal is to have the motor car so designed that the line of drive is approximately straight when the car is loaded. Action then is about equal above and below center when the car is driven over the road. Cars having a considerable angle of drive when under full load have that angle greatly increased as the car is driven over rough roads and spring action takes place. This induces faster wear.

Type of Universals.—All universals formerly used for motor cars were made from metal. These were either the ball and socket, block and trunion, or the split ring types. These features are cared

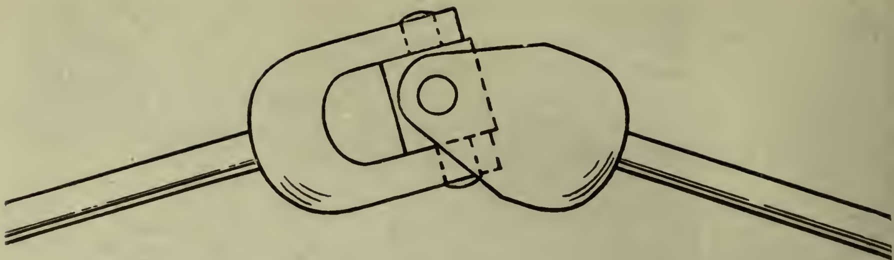


Fig. 100. Simple Metal Type of Universal.

for in every case; that is, arrangement is made within certain limits for the transmission of power from one shaft to the other no matter what angle the shafts may be in with relation to each other. One other provision is also made. That is the slip joint.

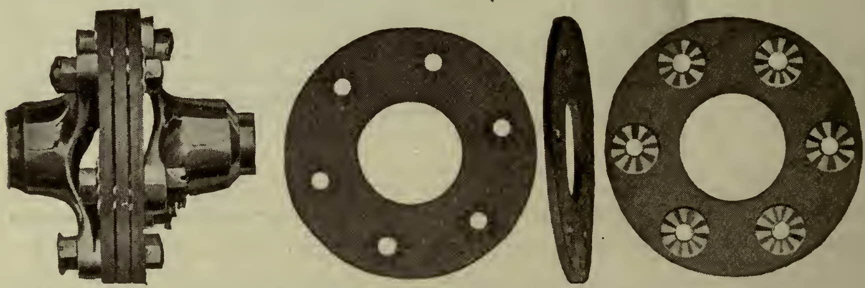


Fig. 101. Thermoid Hardy Fabric Universal in Detail and Assembly.

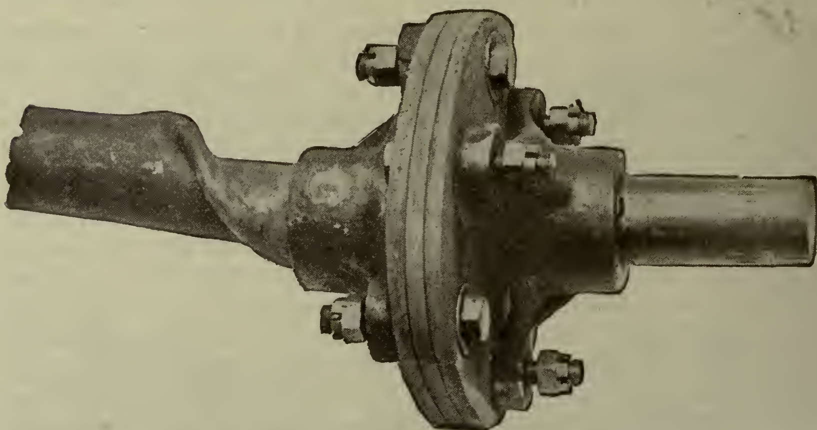


Fig. 102. Result of Thermoid Hardy Strength Test.

Slip Joint.—When the rear springs are in action the distance between the transmission and the rear axle is constantly changing. When the springs are compressed and when they rebound the distance is first shortened and then lengthened. Provision for tak-

ing care of this difference is made within the universal joint in what is known as the slip joint. Referring to Fig. 98 it will be seen how the spliced shaft moves back and forth within its counterpart.

Fabric Universals.—The Thermoid-Hardy universal is perhaps the foremost one of this type. It consists of a coupling in which the ends of the shafts are permanently bolted to disks of flexible fabric in such manner that there are no metal to metal bearing surfaces. Friction is thus entirely eliminated and no lubrication whatever is needed. The result is a pliable joint of enormous strength and great durability, which requires no protection and no attention. The fabric is so treated that it is impervious to oil and water and no amount of sand and dirt from the roadbed can injure it. The elastic disks act as cushions in the driving shaft, absorbing all the damaging shocks and jolts which are intensified by metal to metal contact. This tends to increase service and protects the other parts of the car used in transmission of power. Another great advantage is the absolute silence of the joints in operation.

The shock absorbing properties of the fabric universal are especially noticeable in starting a car. The engine is called on to move

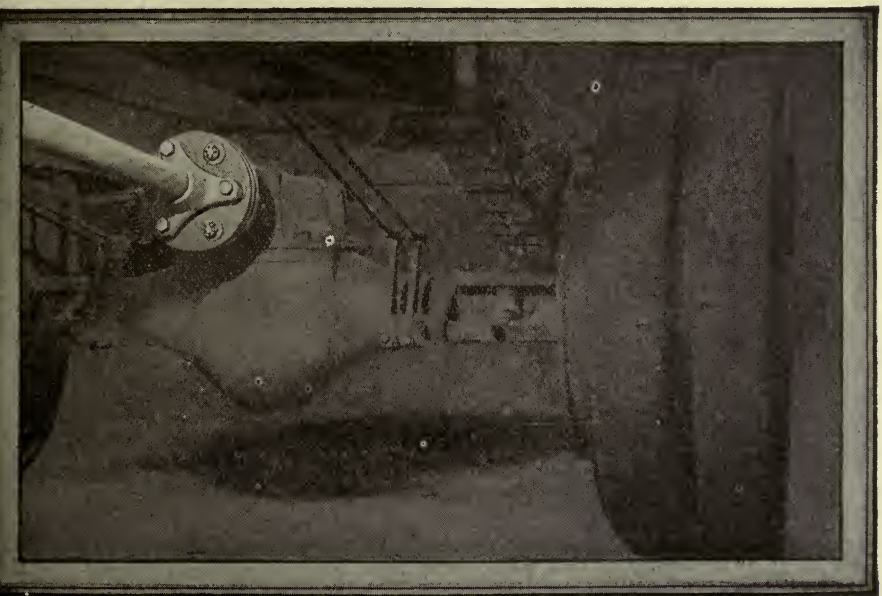


Fig. 103. Thermoid Hardy Universal applied to the rear end of propeller shaft for a truck.

a ton or more of dead weight each time the clutch is left in. The flexible fabric is so elastic that the engine is permitted to take up the load without a sudden clash of metal parts, as the forward end of the

propeller shaft is permitted to turn a bit before causing the axle shafts to start turning. The result is a more even flow of power from the engine to the drive wheels with less severe strain on the running gear. The elasticity also insures an even turning speed as any fluctuations in the velocity of the propeller shaft are taken up and equalized in the joint.

Slip Joint Unnecessary.—One advantage of the flexible fabric construction for a universal is that it allows considerable longitudinal or end play. The need of this for the all metal joint has been explained. The fabric type will care for as much as one inch play. This is as much as is ever found in any well designed car and more than in most cases.

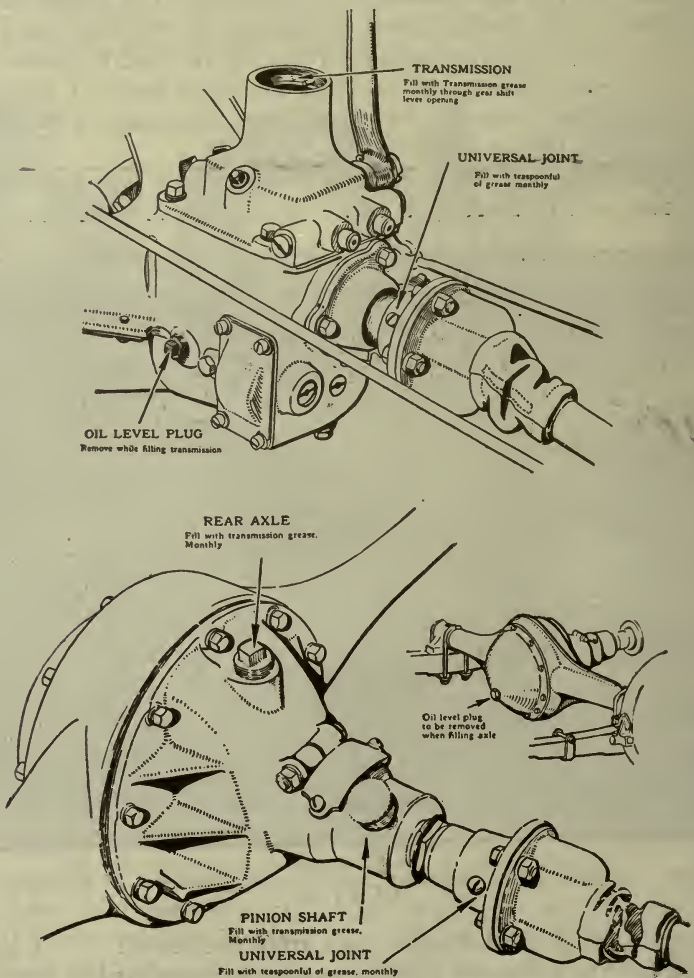


Fig. 104. Universal Joint Lubrication. Note Leather Boots.

A test of this type of universal was made to learn the comparative strength. A picture of the result is shown in Fig. 102. As can be seen the tubular shaft was twisted before the joint proper was damaged at all.

JOB 46. UNIVERSAL JOINT LUBRICATION.

Because of the fact that it will operate without lubrication, the universal joint is perhaps the most neglected unit on the car. Lack of lubrication is certain to cause the metallic joint to deteriorate very rapidly and become very noisy.

1. Raise the floor boards.
2. Locate and remove the filler plug. This is usually a one-eighth or one-quarter inch pipe plug.
3. With a grease gun force into the plug hole a quantity of medium cup grease sufficient to fill the joint about one-half full.
4. In cases where the joint is dry due to neglect of proper filling, or due to replacement of parts or overhaul, it is well to apply a quantity of medium oil to start lubrication and then fill with the cup grease.
5. Never fill the joint entirely.

JOB 47. UNIVERSAL JOINT OVERHAUL.

In all cases where the universal has worn to such a degree that there is an unwarranted amount of backlash, it is necessary to replace the parts subject to wear. In removing the universal joint it is frequently necessary to pull the rear axle. In some cases where two universals are used this is unnecessary. In every case where a torque tube is used it is necessary to pull the axle.

1. Inspect the job to learn what work is necessary.
2. Do this preliminary work and pull the universal.
3. Take the universal to the bench and clean free of all grease and oil.
4. Dismantle completely. Inspect and order the parts needed.
5. Reassemble and replace in the car.
6. Lubricate as suggested in Job 46.

CHAPTER 5

POWER GENERATION AND POWER PLANTS

ENGINES, POWER GENERATION

Power Generation.—In order that the student may properly understand engine care and operation, and more especially all phases of engine repair work, he must have a thorough working and speaking knowledge of the theory of the internal combustion engine. He must know exactly the relation of moving parts to each other, also

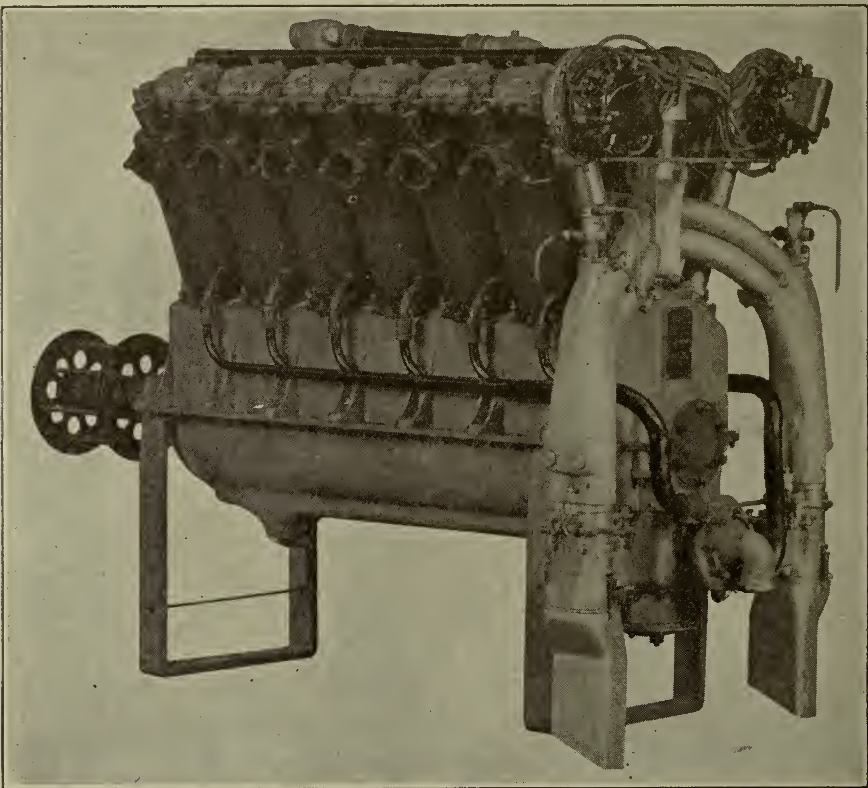


Fig. 105. Packard Liberty Airplane Engine.

the closeness and types of fits between them. He must know the proper functioning or working of each and every part of the engine, be it bolt or shaft, gear or valve, block or gasket, port or piston. Knowing this, he will be in a position to grasp the purpose and meaning of the various systems as the oiling system, the fuel system,

the cooling system, the ignition system, the starting and lighting system, all of which are built in as an integral part of the modern motor car engine or power plant. To these units is added the transmission to make what is termed the unit power plant.

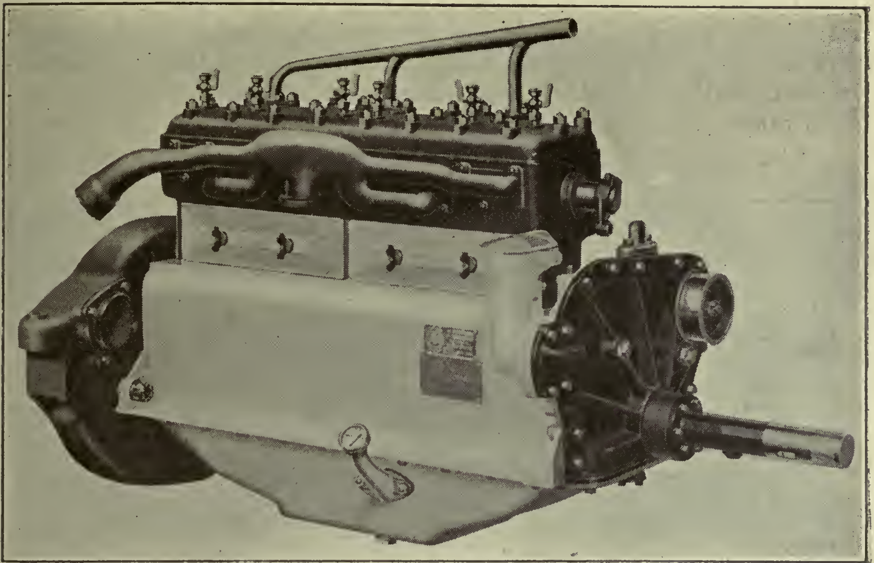


Fig. 106. Continental Engine 7R.

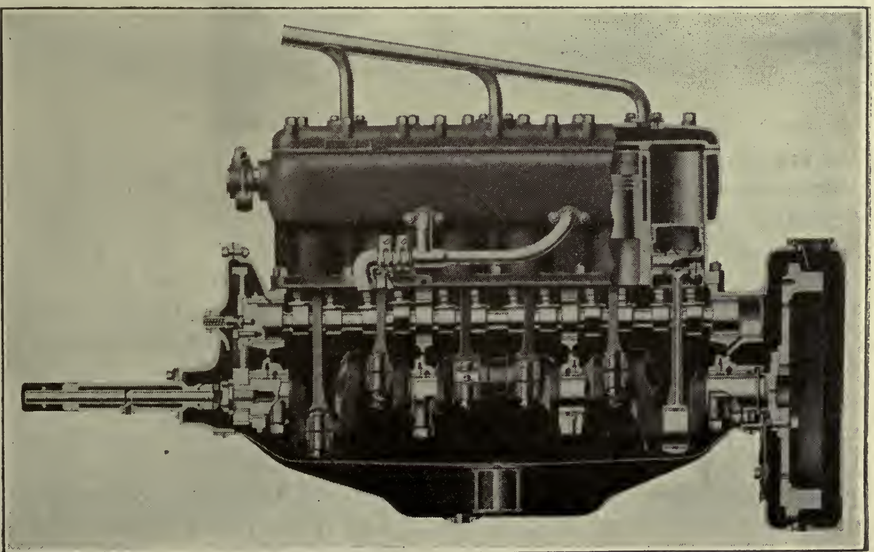


Fig. 107. Sectional View, Continental 7R.

The commercial power plant is a plant where under one or more roofs is housed the means of developing or generating power to be transmitted elsewhere in the community, there to light lamps, to turn machines and to do work. The automobile power plant is that part housed under the hood and used to generate power which transmitted to the rear axle will propel the car. Incidentally it also generates its own electrical energy which is used to ignite the charge within the cylinders, light the lamps, charge the storage battery, and perform other minor operations.

Limitations of space and need of great power have resulted in

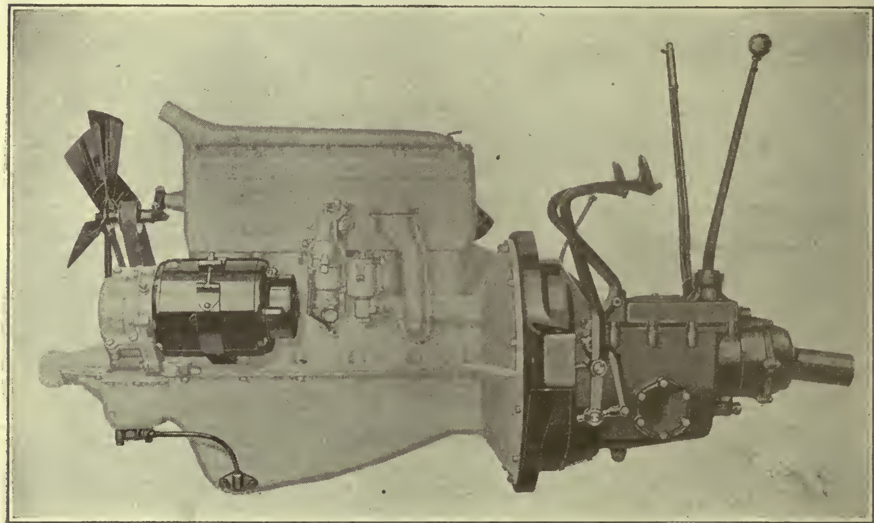


Fig. 108. Dodge Power Plant, Left Side.

the engineers perfecting the design of the various units in a remarkable manner, until nowhere else is to be found such compactness and flexibility of power as in the automotive equipment power plants. The basis of their start was, of course, the cylinder in which a charge of fuel was exploded and made to do work. It is common knowledge that when certain fuels are set afire they burn so fast that the result is termed an explosion. Natural gas, acetylene gas, alcohol, gasoline, kerosene, benzine, nitro-glycerine, and certain other fuels are regarded by all as being dangerous to handle due to their liability, under certain favorable conditions, to explode. Except for the tremendous force or power developed by these when exploded no one would fear them. Coal is handled, usually without a thought of danger or harm from an explosion. Yet, it is quite possible to pulverize this fuel, mix it with the proper amount of air or oxygen and explode it with disastrous or beneficial results, depending altogether

on whether or not the force or power generated from the explosion is directed into the proper channels by means of some mechanical device.

In the case of the internal combustion engine, and more particularly the gasoline engine as used in the motor car, the engineers have designed and built a machine which takes a raw fuel, breaks it into small particles, mixes the vaporized particles with air, puts a quantity of the mixture in a cylinder, forces that quantity into a small space,

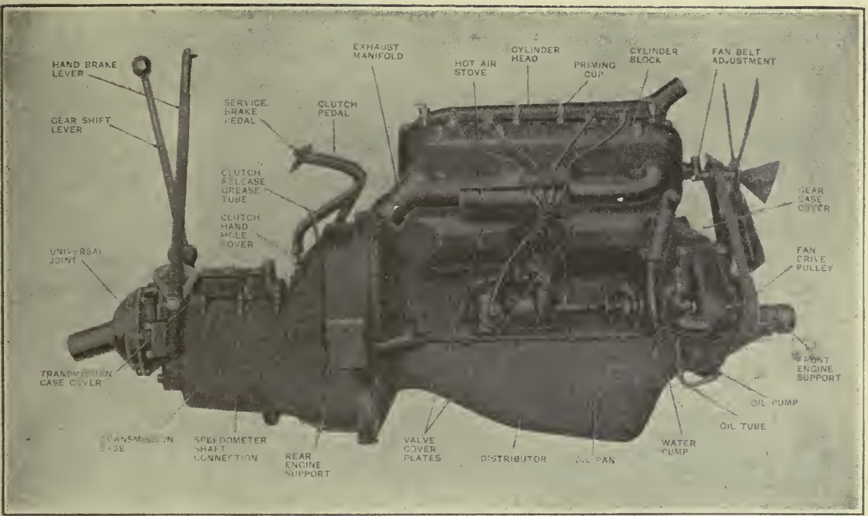


Fig. 109. Dodge Power Plant, Right Side.

sets it on fire thus exploding it, uses the power developed, throws off the burned or useless smoke and gases, and is ready and able to do this complete operation hundreds of times a minute. As this chain of events takes place in first one cylinder and then in another, and in regular intervals of time in each and every cylinder, the engine develops that regular flow of power which is so desirable. All systems saving only the lighting serve one major purpose only, that of generating power and delivering it to the transmission system. Each bit of fuel burned in each cylinder means a bit of power developed and controlled to do the work we want performed. A certain per cent of the power developed within the engine is necessarily used to overcome internal losses as friction, etc., and keep the engine itself in motion. Only the surplus, over and above this amount, is available for driving the car.

Names and Location of Engine Parts.—Whether the engine is a four, six, eight, or twelve cylinder, the general design is quite similar.

Parts used in the construction bear the same names and general relation to each other. Referring to the two cuts of the Dodge Unit Power Plant and the cut of the Dodge Engine Section (Figs. 108, 109, 110), the proper names of most engine details may be learned.

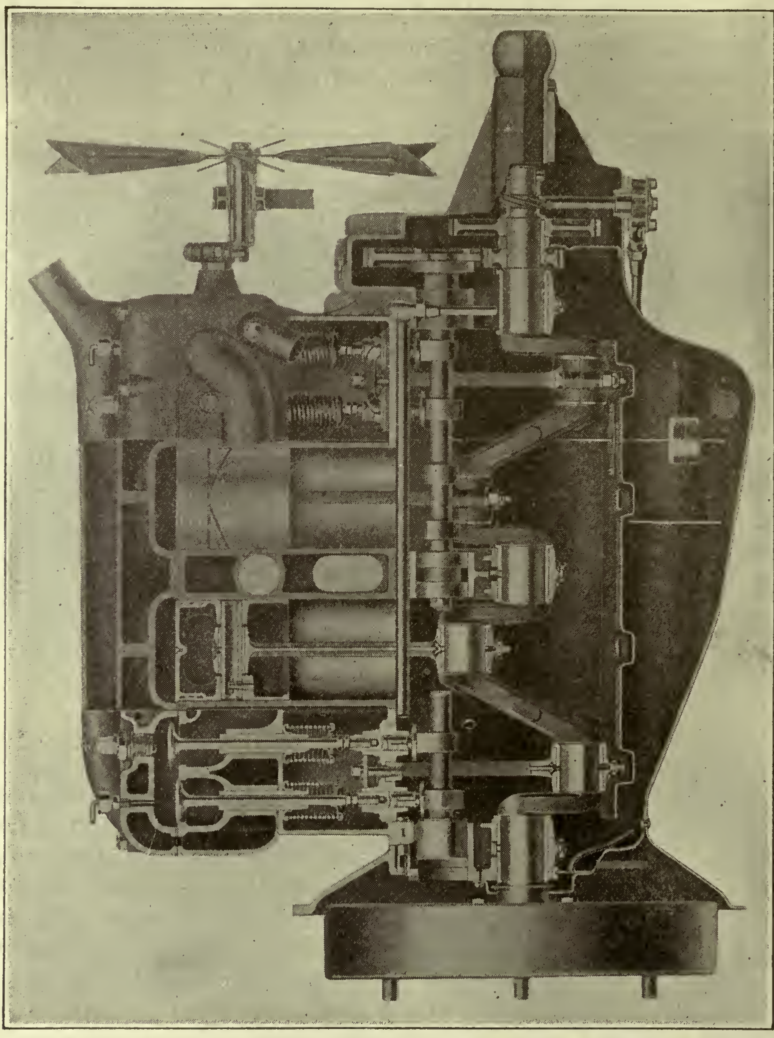


Fig. 110. Dodge Engine Section.

Other cuts appearing elsewhere will also prove of help to the student in becoming familiar with general design and names of engine parts.

Operation.—Since the gasoline engine is not capable of generating power until first set in motion from an outside source of energy, an electric starting motor has been incorporated in most cases. Press-

ing the starting switch draws current from the storage battery, which drives the starting motor, which in turn drives the crankshaft, or turns it over with all the parts directly related to it, in fact all the moving parts of the engine, until a fuel charge has been drawn in, compressed and fired. When this first charge is fired the engine becomes active, having now power within itself to keep the parts turning. However, it is so arranged that in another half revolution, in the case of a four, another charge is fired in another cylinder, in another half revolution another charge is fired in the third cylinder, in still another half revolution the fourth and last cylinder is fired, and after still another half revolution of the crank shaft the cylinder first to fire is fired for the second time. Each of the other follows

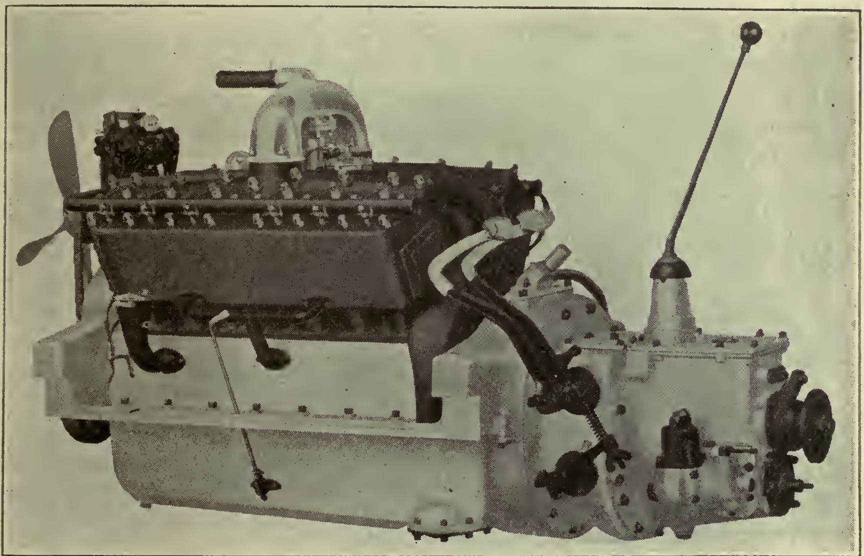


Fig. 111. Packard Twin Six Unit Power Plant.

in its regular turn, thus keeping the engine operating and developing the desired power. The operation of the engine with reference to handling fuel is called the four cycle principle, more properly called the four stroke cycle.

The Four Stroke Cycle.—A cycle is a completed chain of events which leaves the operation finished so that the next event due is the one with which the start was made. To illustrate, consider the cycle of seasons. The year which is one cycle of seasons is completed every 365 days. These 365 days are divided into twelve months while the twelve months are divided into four seasons, winter, spring, summer, and fall. Since the birth of Christ, 1921 of the cycles of seasons have been completed and the 1922nd is well under way. The

seasons occur in order always. The Creator has arranged the mechanical features of the Universe so that no other order is possible. The earth revolves on its axis, follows on its way on its orbit, the sun retains its position and as a result we regularly have winter, spring, summer, fall, etc., etc., cycle of seasons after cycle of seasons.

In designing the gas engine, engineers have found that there are four events or operations which must always follow each other with unvarying regularity. If they occur in any other manner for any reason, the engine fails. Practice is absolutely dependent on principle. To obtain power from any cylinder of any engine the events for that cylinder must be in the following order: Intake of air and fuel, compression of charge, explosion of charge and development of power, exhausting of burned gases thus completing for that cylinder the first cycle of operations. However, the engine does not stop with the completion of the cycle but goes immediately into another cycle until each cylinder has a continuous chain of events occurring in it, as intake, compression, power, exhaust; intake, compression, power, exhaust; and on and on.

Firing Order	One Cycle			
	One Revolution		One Revolution	
	One Stroke	One Stroke	One Stroke	One Stroke
1	P	E	I	C
3	C	P	E	I
4	I	C	P	E
2	E	I	C	P
1	P	E	I	C
3	C	P	E	I
4	I	C	P	E
2	E	I	C	P
1	P	E	I	C
3	C	P	E	I

Fig. 112.

The student will remember that while one cylinder is running its cycles the others are falling in line with theirs, so that the events occurring in each cylinder might be compared as given in Fig. 112, representing the order in the Dodge engine. Also remember that a cycle requires four strokes of the piston, and two revolutions of the crankshaft and flywheel to complete it. A stroke of piston and piston rod is either from top to bottom or from the bottom of the cylinder to the top of it.

One stroke equals ½ revolution or ¼ cycle.

Two strokes equal 1 revolution or ½ cycle.

Three strokes equal 1½ revolutions or ¾ cycle.

Four strokes equal 2 revolutions or 1 cycle.

In the diagram the width represents the length of a cycle. Two revolutions make one cycle. Four strokes make one cycle. The firing order of the cylinders is 1-3-4-2. Supposing cylinder 1 is on power, cylinder 3 must be on compression since in this case it fires next. Cylinder 4 must be on intake

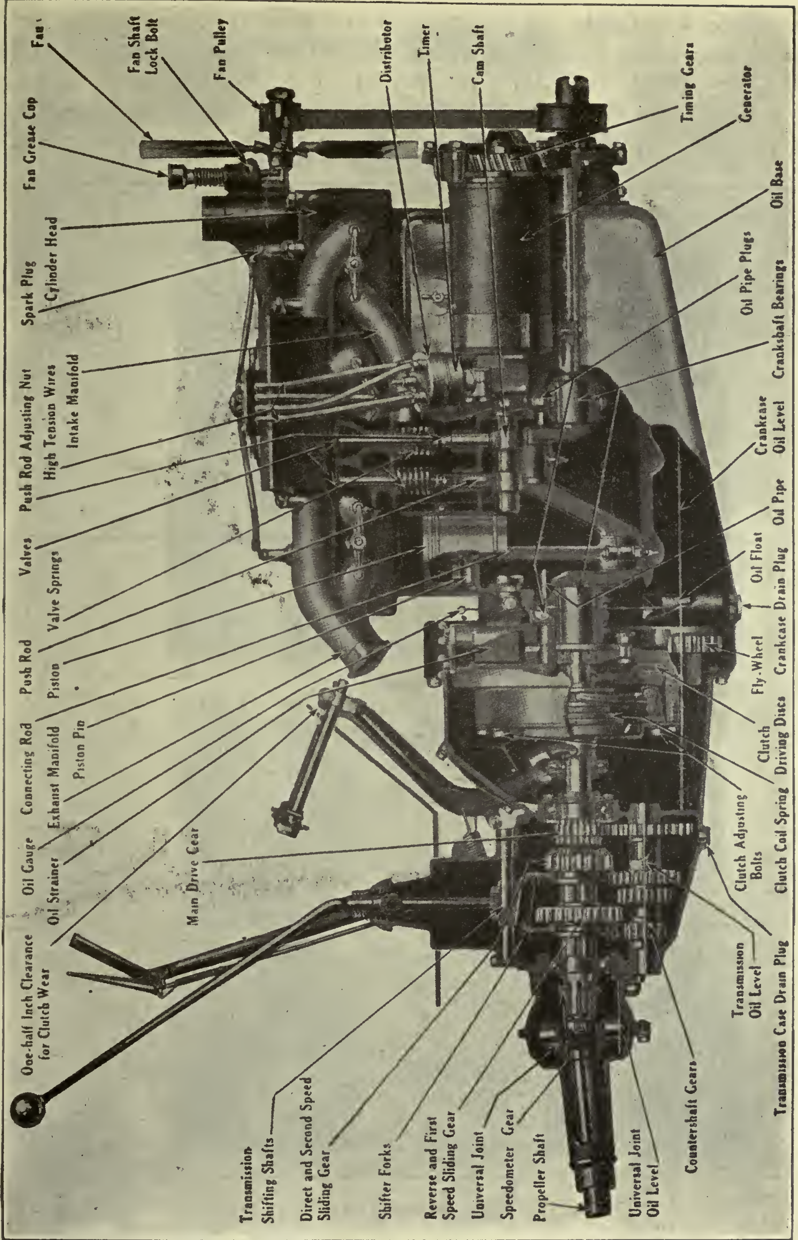


Fig. 113. Overland Four Power Plant with parts identified.

while 3 is compressing, and on compression while 3 is firing. Two, which is the fourth cylinder to fire, must be on exhaust while 1 is firing, because it will be on intake when 3 is fired, and on compres-

sion when 4 is fired. In the case of the four cylinder engine, at no time is the same event occurring in two or more cylinders at the same time. For each half revolution of crank shaft and flywheel one is fired, one exhausts burned gases, one draws in a new charge, and the other compresses a fuel charge. There are always as many

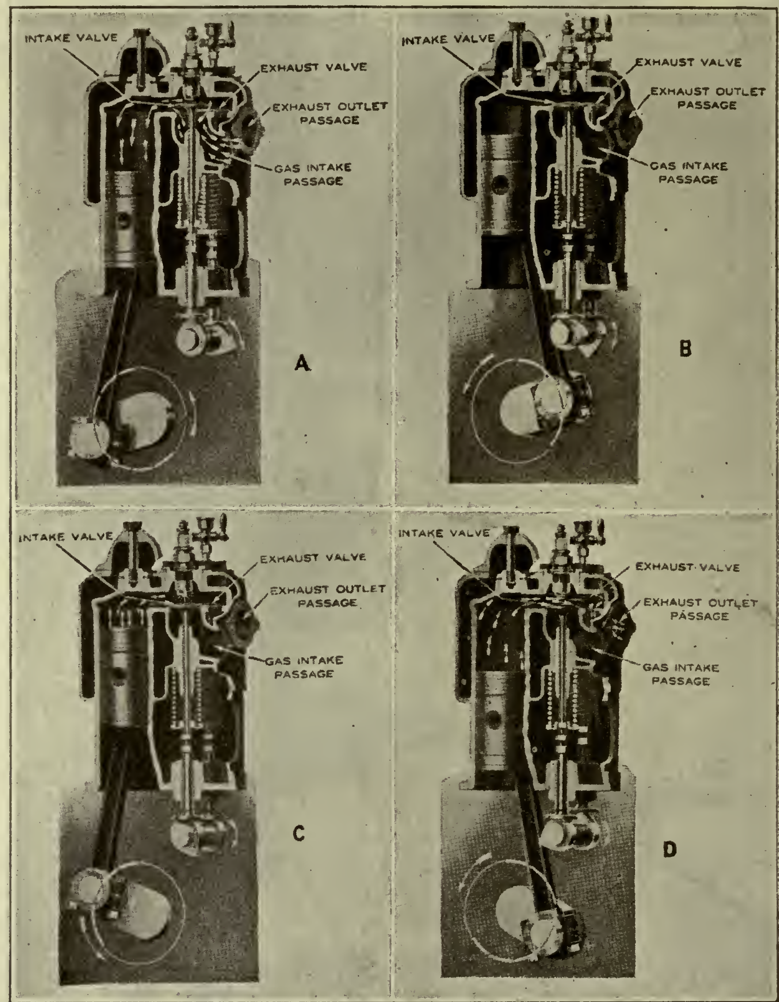


Fig 114. Four Stroke Cycle illustrated.

cycles in operation in an engine as that engine has cylinders. In a four cylinder engine four cycles are in operation; in a six, six cycles; in an eight, eight cycles; and in a twelve, twelve cycles. Each cycle will be completed in two revolutions of the crankshaft. Since in the case of the four cylinder engine, four cycles are in

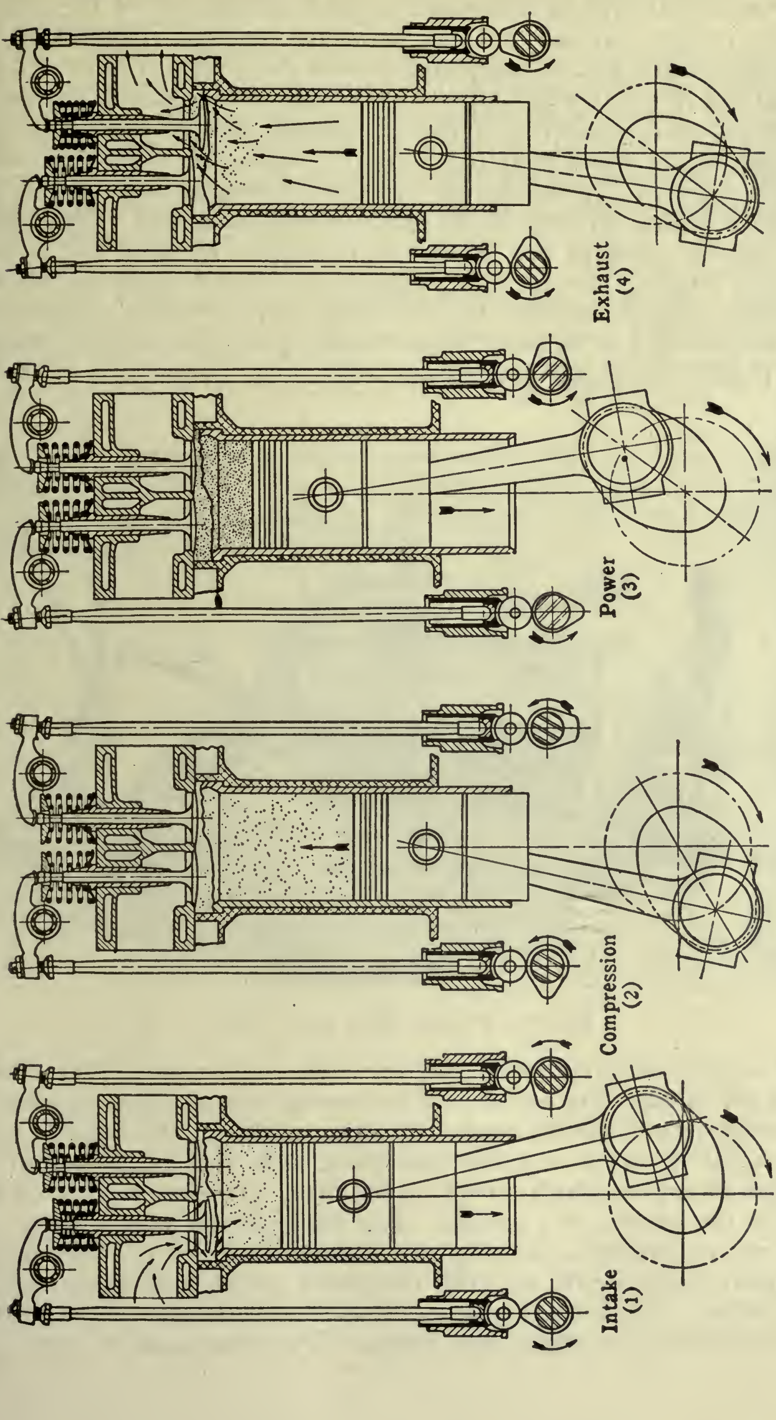


Fig. 115. Four Stroke Cycle Diagram. (Courtesy Marmon.)

operation four will be completed in two revolutions of the crankshaft; in the six, six will be completed in two revolutions; in the eight, eight will be completed, and in the twelve, twelve will be completed in the two revolutions. One-half the number of cylinders represents the number of cycles completed each revolution of the crankshaft, and since there is one power impulse for each cycle completed, one-half the number of cylinders represents the number of power impulses per turn of the flywheel and crankshaft. This gives two power impulses per revolution of engine flywheel for a four cylinder engine, three for a six cylinder, four for an eight, and six for a twelve cylinder engine. From this is easily learned the reason for the more even flow of power as the number of cylinders is increased.

Cycles Completed per Minute.—Since the above figures repre-

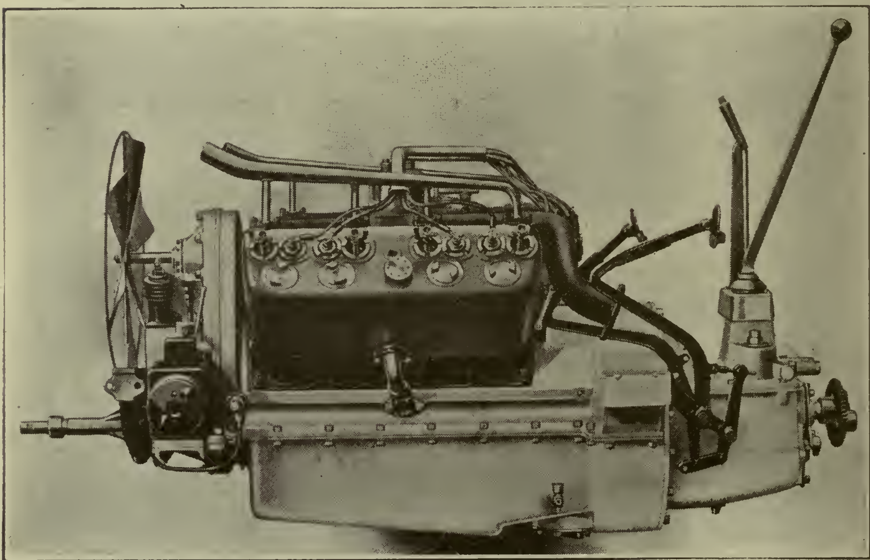


Fig. 116. Peerless Eight Power Plant.

sent actual conditions within the four cycle engines, and 1,000 revolutions per minute may be taken as an average engine speed in driving, it would be well for the student to gain an idea of the rapidity with which the events in a cycle take place, and what it has meant to design an engine which would insure their occurring in right order and in the fraction of a second. In a four cylinder engine there are two power impulses, meaning two completed cycles per revolution, therefore there would be 2,000 completed cycles within the engine per minute. Since each cycle means four events there will be 8,000 events within the engine per minute. Two thousand of these are

intakes, 2,000 are compressions, 2,000 are power impulses, and 2,000 are exhaust operations.

In a twelve cylinder there would be 6,000 cycles completed per minute which means 24,000 events or operations, which include 6,000 power strokes, 6,000 exhaust strokes, 6,000 intake strokes, and 6,000 compression strokes. The student would find interest in estimating the number of events or operations within the six and eight cylinder engines, and then the number occurring in a twelve cylinder when driven at its highest rated speed. While one year of 365 days is needed to complete a cycle of seasons, as many as 1,700 cycles may be completed within a single cylinder of a modern engine in a minute. Multiplying this by the number of cylinders gives a rather accurate figure for the modern high speed engine at its best or greatest speed. Each one of these cycles requires four strokes of a piston to complete it.

How it has been possible to have this number of operations occur in such short spaces of time will be learned in studying the functioning of engine parts, particularly valves, cams, timing gears, pistons, camshafts, and crankshafts.

CHAPTER 6

FUNCTIONS OF ENGINE PARTS

TROUBLES AND REPAIRS

Crank Case.—The crank case is used as a rule to carry all other parts of the engine and is in turn carried by brackets cast integral with it or bolted to it. The outer ends of these brackets are attached to the frame. If there are three of these brackets supporting the weight of the engine, the engine is said to have three point suspension; if four, four point suspension. The three point suspension is most in favor as it permits of greater movement within the car frame without throwing strains onto the engine itself. The crank case is

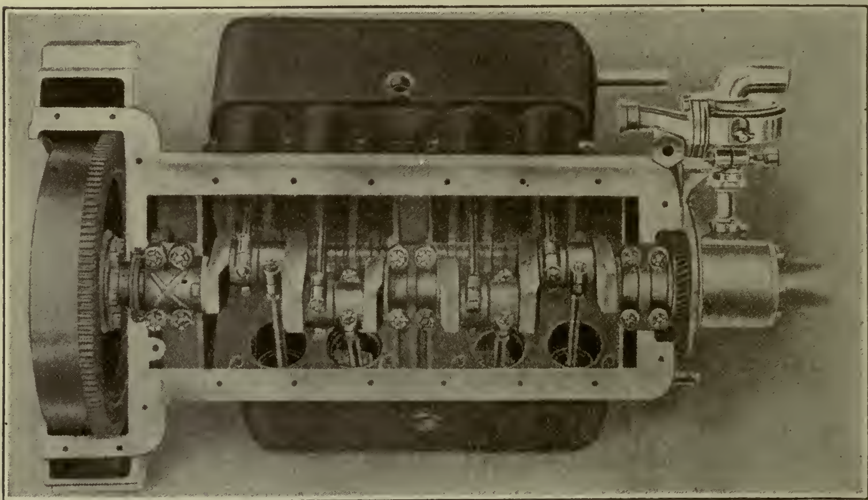


Fig. 117. Standard Eight with Pan or lower half of crank case dropped. Note position of Pistons, Rods, etc.

usually divided into upper and lower halves. The engine brackets may be attached to either part but are found more often on the upper half. This part is usually the one carrying the main engine bearings. When this arrangement is used, the upper part is called the crank case while the lower part is called the oil pan. This arrangement frees the oil pan of all weighty parts and permits of the pan being dropped for bearing inspection, either rod or main bearings, also for cleaning, without removing the engine from the frame of the car. Fig. 119, showing the Marmon crankshaft mounted in the crank case with oil pan removed, illustrates this.

While the above is the most approved design, engines may be

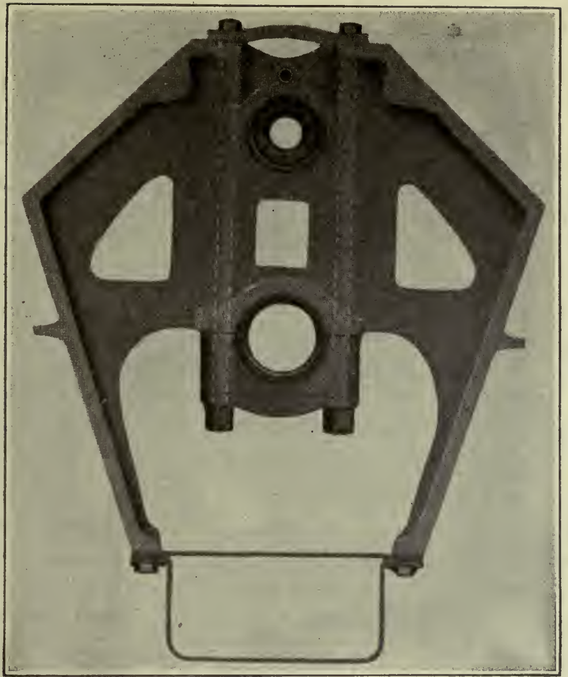


Fig. 118. Sectional View of Cadillac Crank Case.

found with the brackets on the lower half, and even in rare instances crankshaft bearings may be found in the lower half of the crank case. In still other instances the crank case is cast in one piece with inspection plates on the sides to be removed for minor repairs. This is

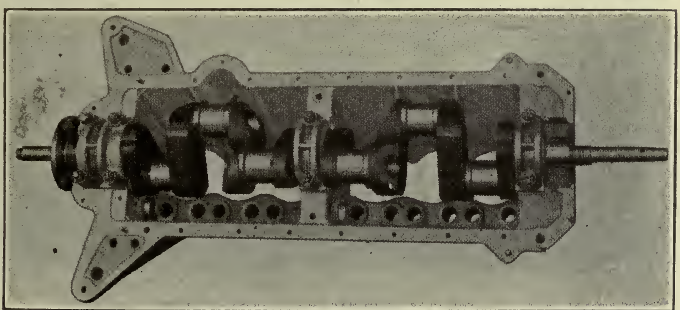


Fig. 119. Marmon Upper Half Crank Case.

called the barrel type case. For major repairs the engine must be lifted from the frame of the car. Then all cylinder blocks must be pulled from the case as well as all rods and pistons removed from the crankshaft, after which the shaft with the main bearings loosened and

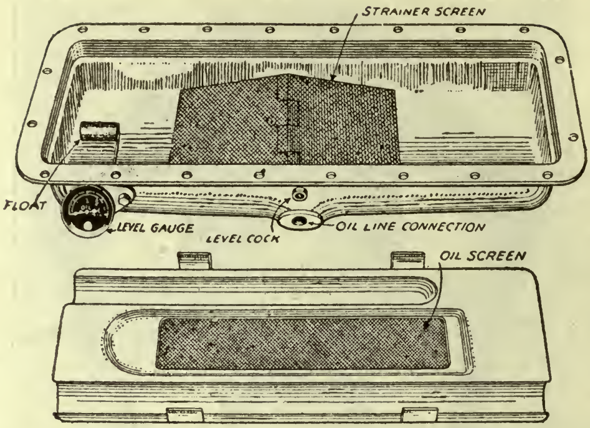


Fig. 120. Cole Eight, Oil Pan and Tray.

removed may be pulled from the end of the case through the opening left when the main bearings were removed. It is also well to remove the flywheel before attempting to remove the shaft as there is less danger of harming bearings or shaft without its added weight. In the case of some eights the crank case is split vertically and the shaft bearings attached to one-half of it.

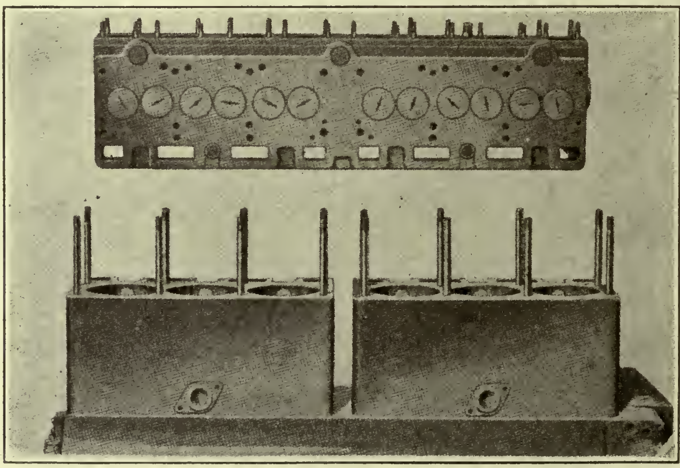


Fig. 121. Marmon Cylinder Blocks with Head Removed.

Owing to the size of the crank case, aluminum has been used very extensively in casting them since it materially reduces the weight. However, as this metal is always costly, an increasingly large number of the oil pans are made from pressed steel. In some instances the upper half is made from cast iron and is supported with pressed steel brackets.

In a number of instances the upper half of the case is cast integral with the cylinder casting, and in some instances the barrel type case is cast integral with the cylinder blocks. Either method makes for fewer parts. Each has its own peculiar advantages and disadvantages as will be noted in study and shop practice.

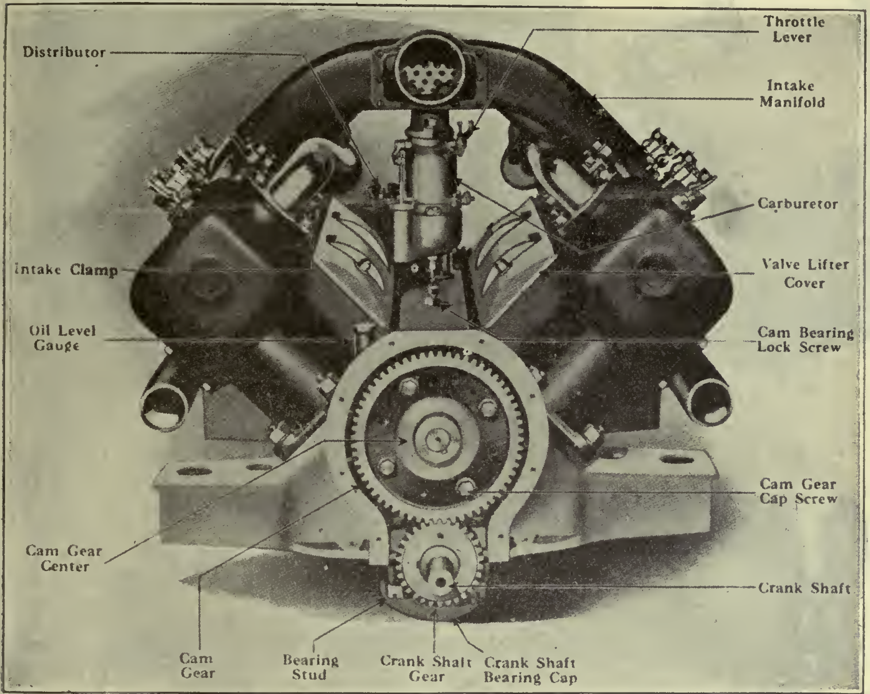
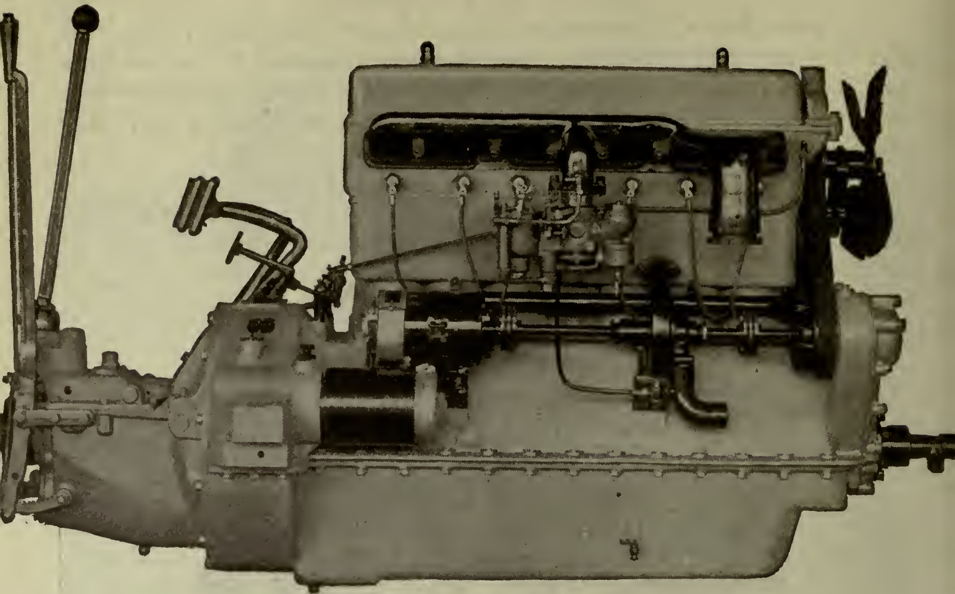


Fig. 122. Front View Apperson Eight, L Head Motor.

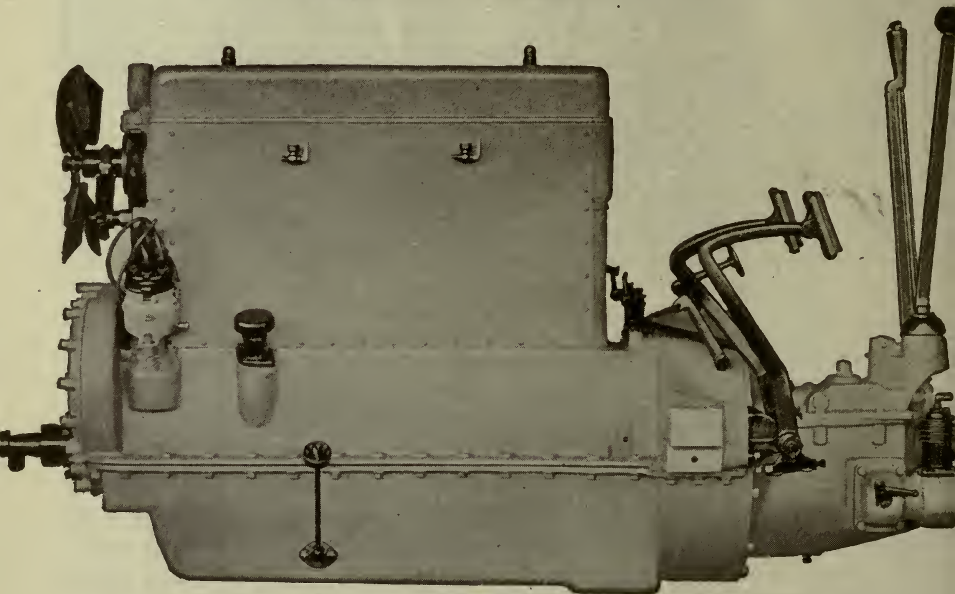
In all cases the lower half or oil pan is provided with suitable oil levels depending on the type of oiling system in use.

Cylinder Blocks and Cylinders.—The function or purpose of the cylinder is to provide a place for the piston to move up and down in. In it is placed and fired the charge of fuel which develops the power All ports, gaskets, valves, etc., must be made to fit correctly and be kept in good condition, else when the charge is fired the gases will escape from the cylinder without doing their duty which is to drive the piston down in the cylinder. The piston and piston rings must be well fitted to the cylinder wall which must be perfectly smooth and true, else the gases will escape down past the piston into the crank case, again failing to fulfil their duty.

Cylinders are cast singly, in pairs, in sets of three, or in blocks of four or six. The water-cooled single cylinder is no longer used on automobile engines to any extent, although it is perhaps the



Right Side with Accessories.



Left Side with Concealed Valve Mechanism.
Fig. 123. National Six, I Head.

best in airplane design where a thin steel cylinder has a still thinner steel shell welded over it to provide space for the cooling water. In the case of the automobile engine these spaces for the water are cored out in the engine casting. The result is a neat efficient cylinder block casting.

Engine Types.—Engines are spoken of as being either T, L, I, or F heads due to a general resemblance to the form of the letters when the engine head and cylinder casting is viewed in cross section or from the end. The L is considered as inverted, and in point of number of manufacturers using it is considered most popular. Four

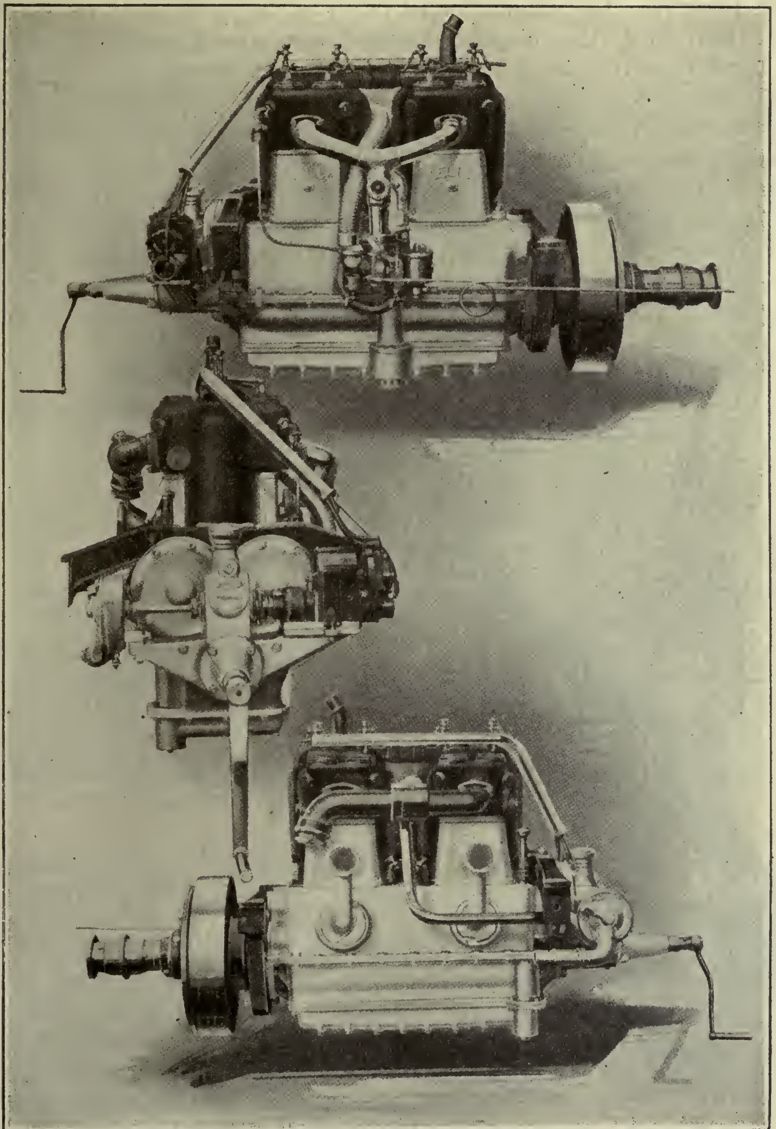


Fig. 124. Kelly T Head Truck Engine.

cylinder L head engines are mentioned as well as four cylinder T head, four cylinder I head, or six cylinder T head, etc.

Cylinder Heads.—The L head motor is perhaps the simplest of all designs. It is very popular in fours, eights and twelves where the heads are usually made removable. The I head, or as termed by some manufacturers the "valve in head", is popular in sixes and in some twelves. The term "valve in head" is somewhat misleading as it might imply that no other construction would permit of valve in the head construction. As a matter of fact motors are in use in which the valves are in removable L heads. The term "I head" is preferable. The T head has usually been cast with a solid head although this method is not imperative. It is more popular in sixes perhaps than elsewhere. Since two cam shafts are required to operate the valves, the T head motor is more expensive to build than an L head of the same type. Valve size, however, is not limited. The valves of all other types of motors are operated from the single cam shaft. The F head has one valve overhead and one in an L projection operated from the valve tapped direct.

In considering cylinder block design and construction, it is well to remember that any engine having any of the standard numbers of cylinders might use any of the standard forms of heads cast integral or removable, and that it might be built in either the vertical or V type. It is also well to remember that price, purpose, accessibility and manufacturing practice have held and will continue to hold design within certain pretty well defined limits. For instance, we check off the items removable T head V type motor. Such a motor could be built, but for obvious reasons is not being built.

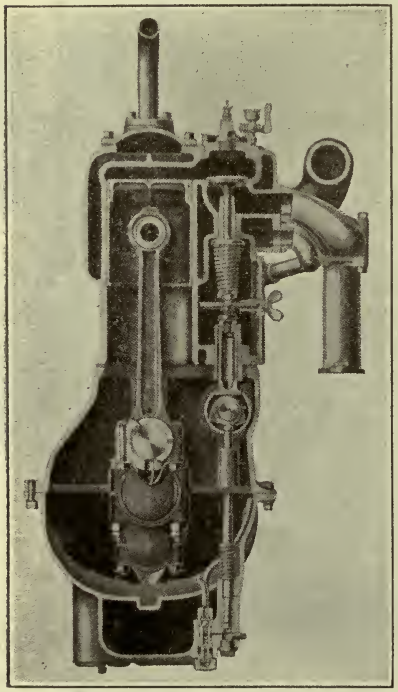


Fig. 125. Engine Cross Section. Continental Model E.

Cylinder Care and Repair.—Proper lubrication of cylinders is the best safeguard for them and will do much to prolong their life. All the features tending to cause overheating of the engine contribute to rapid wear of the cylinders. Proper care of the engine will maintain them in condition for much service, but wear is bound to occur to some extent due to the side pressure of

the piston when it is under the stresses of compression or power development. Another feature contributing to cylinder trouble is the constant heating and cooling of the cylinder metal. This will induce strains in the cylinder block and a new engine is almost certain to come out of true to some extent due to this cause. This trouble may be corrected rather automatically by the new piston and rings wearing to their seat as the car is operated over the first

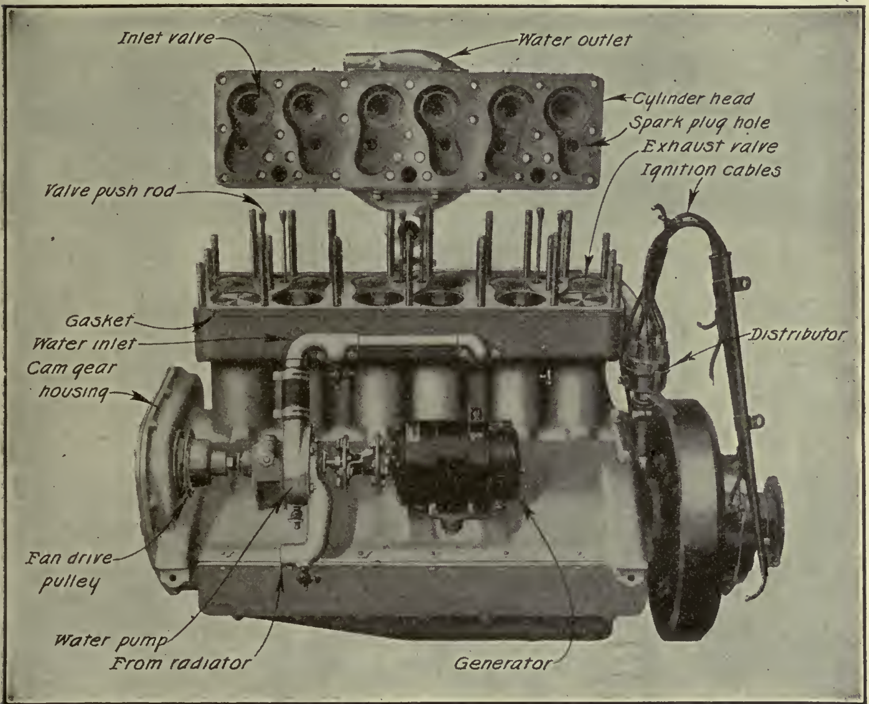


Fig. 126. Reo Removable Head.

500 or 1,000 miles. To correct the few thousandths of an inch which normal service will leave a cylinder out of round, it is frequently necessary only to lap in a new piston, or if the trouble is of a more serious nature, it may be necessary to rebore the cylinders and fit over-size pistons.

Scored Cylinders.—The causes which result in scored cylinders are lack of lubrication, foreign substances in cylinder as carbon, grit, spark plug porcelains, broken rings, loose piston pins, etc. The latter type of score is the hardest to remedy. A score is a cut or a scratch formed in the cylinder wall as the piston moves up and down in the

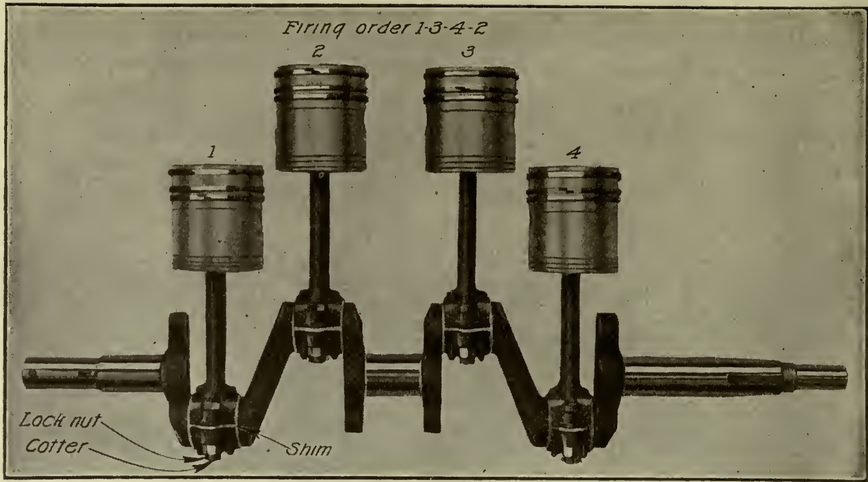


Fig. 127. Three bearing 4 throw crank shaft with pistons and rods assembled (Reo).

cylinder. To remove these score marks it may be sufficient to lap or grind them out using an old piston or block of wood for a dummy. If severely scored, reboring up to 1/32" oversize will usually serve to remove it. If the score is a deep one, it will be necessary to have

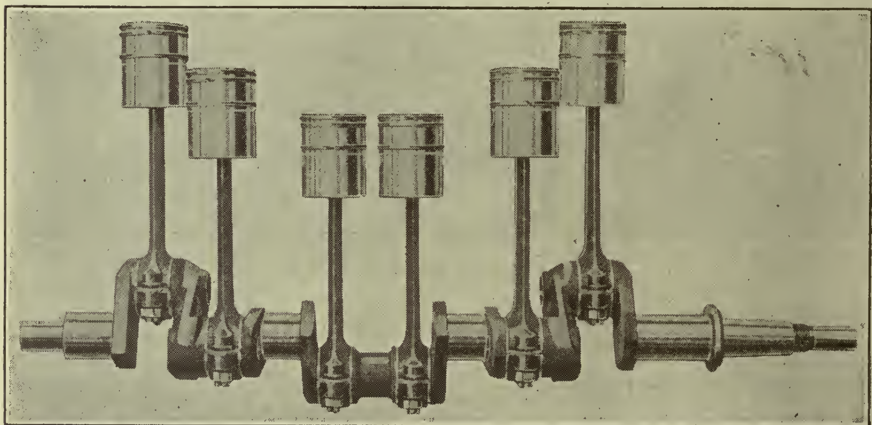


Fig. 128. Four bearing five throw crank shaft with pistons and rods assembled (Reo).

the score filled in by welding, after which the inside of the cylinder will have to be machined and new piston and rings fitted. The most usual practice is to replace the badly scored cylinder block with a new block as it is the one certain method of effecting a permanent

repair. This may mean all new pistons and rings, but the mechanic must be guided by circumstances in determining this.

Frozen or Bursted Cylinders and Cylinder Heads.—Some cylinder blocks are protected in a measure from freezing by means of small lead or steel plugs fitted into the water jacket. When expansion due to freezing occurs within the water jacket, these plugs may be forced

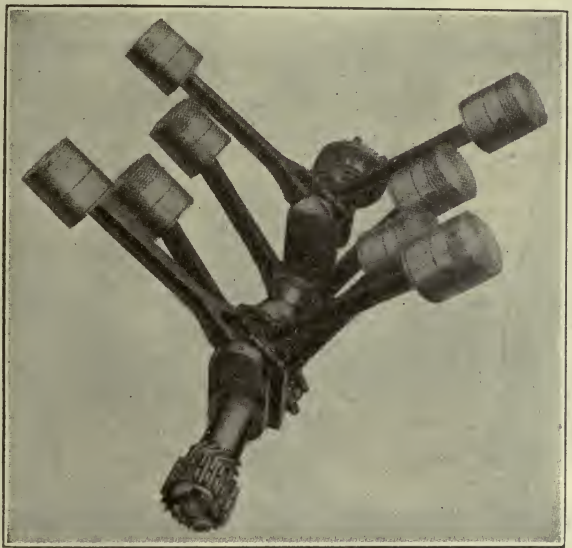


Fig. 129. Cadillac Eight Crank Shaft Assembly.

out, thus relieving the internal pressure, as they are designed to give before the jacket cracks. In a bad case of freezing they may not save the casting. In the majority of cases these plugs are not provided. A badly cracked block or head is usually replaced with a new one. Repairs are made on minor breaks by several methods.

A small crack or break may be repaired by using X-Liquid, Neverleak, or similar radiator repair compound to seal it from the inside. These preparations are so compounded that they solidify only when steamed out through the crack. No harm will result from leaving them in the radiator a time after the leak has stopped.

Crank Shafts.—The function of the crank shaft is to receive the power delivered to it by the piston and piston rod, from the cylinder, and transmit this power to the transmission. While doing this it must be so arranged as to care for all cylinders at correct intervals of time.

As the number of cylinders have been increased the design and

construction of the crank shaft has necessarily become more and more complicated. High speed motors, too, have exerted a decided pressure toward their refinement. The strains and stresses coming on a shaft are numerous and varied. If a shaft is permanently sprung

Fig. 130. Two Bearing, Three Throw, Counterbalanced Crank Shaft.

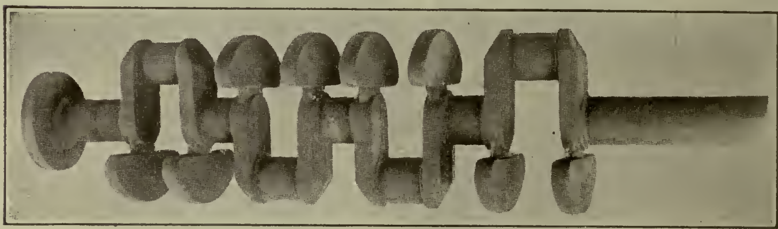


Fig. 131. Five Bearing, Four Throw, Counterbalanced Crank Shaft.

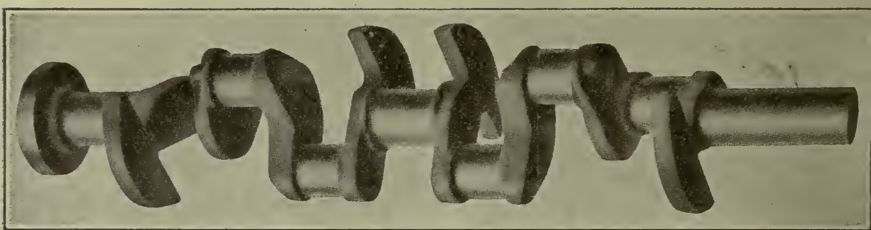


Fig. 134. Three Bearing, Six Throw, Counterbalanced Crank Shaft.

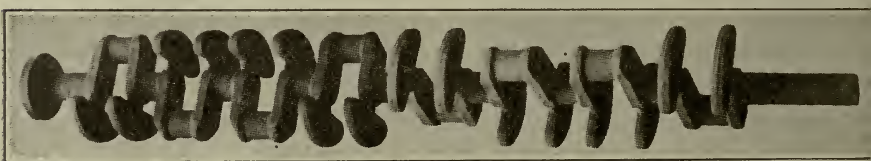


Fig. 136. Nine Bearing, Eight Throw, Counterbalanced Crank Shaft.

a few thousandths of an inch out of true, it will make trouble by binding in the main bearings. While it must be heavy enough to resist springing, it must be kept as light as possible to prevent undue

vibration and weight. To decrease weight and insure strength additional bearings are used. More main crank shaft bearings or engine

Fig. 132. Three Bearing, Four Throw, Counterbalanced Crank Shaft.

Fig. 133. Four Bearing, Five Throw, Counterbalanced Crank Shaft.

Fig. 135. Seven Bearing, Six Throw, Counterbalanced Crank Shaft.

bearings mean a longer engine as well as additional trouble in lining up the bearings.

Type of Crank Shafts.—Crank shafts are plain or counter-balanced. They are made for motor car engines of the four, six, eight, and twelve cylinder types. Usually drop forged steel is used. Sometimes the counterbalancing weights are bolted on but one-piece construction is considered standard practice and the best. The counterbalance shafts shown in Figs. 130 to 136 are forgings not machined. In speaking of crank shafts they are distinguished first by the number of bearings, second by the number of throws, third counterbalanced or plain, and fourth by the number of cylinders cared for. In the case of the Ford engine the crankshaft, Fig. 161, is a three bearing, four throw plain shaft for a four cylinder engine. In the case of the Overland, Fig. 192, the crank shaft is a two bearing, three throw plain crank shaft for a four cylinder engine. In the case of the center throw, two rod bearings are accommodated on the one throw. Some of the older cars used a five bearing, four throw plain shaft for four cylinder motors, and seven bearing, six throw shafts for the six cylinder motors. This was usual practice where the cylinders were cast separate. In fact, the method of casting cylinders has had a very definite bearing on the style of shaft to be used. If main engine bearings are to be used between each pair of throws, or any pair of throws, the distance between cylinders must be increased a distance equal to the length of the bearing. This has a very decided effect on the length of the finished motor. With the pairing and tripling of cylinders in block casting the number of bearings to the shaft were decreased. Where a center bearing is used on a four cylinder engine the two cylinders in the center of the block are farther apart than the two on either end. In the case of the six having four main bearings on the shaft the cylinders are again paired even though all are cast in block, while if three cylinders are grouped closely together at either end of an engine group cast in block, the shaft used will have but three main bearings. These statements apply particularly to passenger car motors. In the heavy duty motors a larger number of main bearings is the usual practice. In the case of airplane motors where single or separate cylinder castings or units are used the shaft is usually provided with one more main bearing than there are throws to the shaft.

Crank Shafts for V Type Engines.—These are the same as those for the four or six cylinder motors. That is, a shaft similar to that used in a four is used in an eight, and a shaft similar to that used in a six is used in the twelve cylinder motors. Usually the shaft is heavier and main bearings larger. Two methods are used in attaching the rods. In one case, as the Standard 8 shown in Fig. 117, the

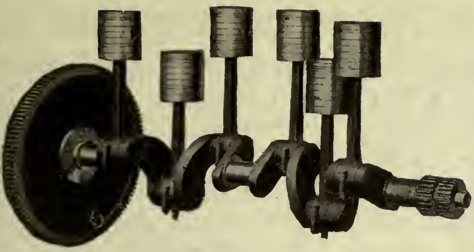
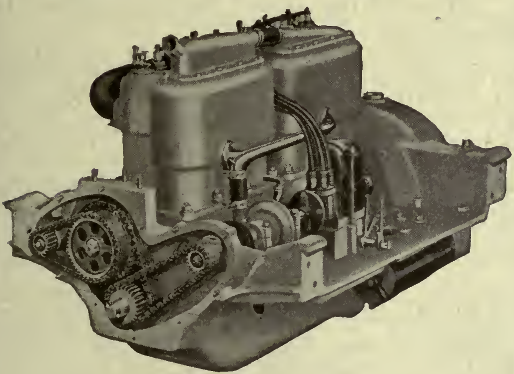


Fig. 137. Chandler Crank Shaft Assembly. Right Hand. Firing Order 1-5-3-6-2-4.

rods are fitted side by side while in other cases, as that of the Cadillac 8 shown in Fig. 129, the rods are yoked together.

Technically speaking there are no such crank shafts as four cylinder and six cylinder, but rather four or six throw shafts for the four or six cylinder motors. To determine the type of shaft, count the number of main bearings, and the number of throws, note whether plain or counterbalanced, and the number of cylinders provided for as indicated by the number of rod bearings or crank pins.



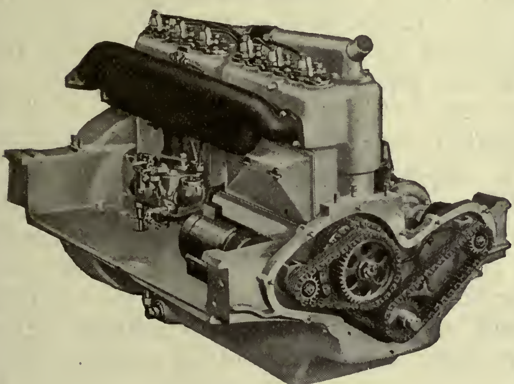


Fig. 138. Chandler Engine.

Right and Left-Hand Shafts.—In the shafts for the fours and eights there are no right or left-hand shafts, but in those of the sixes and twelves a shaft may be either right-hand or left-hand depending on the relative position of the center throws with reference to the end throws. Place the end throws, that is number one and six, on top dead center. When facing the engine from the front the student can determine whether the shaft is right or left-hand. If the center throws are to the right side, 120 degrees advanced over the end ones, 1 and 6, the shaft is right-hand. If the center throws, 3 and 4, are 120 degrees to the left, the shaft is left-hand. A right-hand shaft would be a left-hand shaft if it were turned end for end in the engine. Right and left-hand has no reference to the direction of rotation of the shaft as all American engines are made to turn to the right. The point of interest here is the bearing the

shaft construction has on the firing order of the engine and its influence on cam shaft design.

Six Cylinder Firing Order.—The most popular firing order for the right-hand shaft is 1, 5, 3, 6, 2, 4, while for the left-hand the most popular and usual order is 1, 3, 5, 6, 4, 2. There are several other firing orders for each shaft, but the best distribution of power impulses is secured with the above orders. Attempts to memorize firing orders lead only to confusion except in cases where only one or two makes of engines are handled. The student should become so familiar with the engine principle that a study of piston and valve action would give him the proper firing order for any engine in question, in first hand investigations.

Crank Shaft Troubles.—Serious crank shaft troubles are rather rare as a rule. Occasionally a shaft may be broken in which case a new one is usually installed. This of course means that the bearings must be fitted to it, either burned in or scraped in. In many cases it is best to install all new bearings with the new shaft. Crankshafts may be welded, but the practice is not to be recommended for ordinary repairs. In a case where no new shaft is available it is standard practice.

Foreign substances such as dirt, grit, steel chips, etc., sometimes work their way into the bearings and may score the shaft very badly. Failure of the oiling system is also responsible for scored and worn bearings. Upon the degree of injury depends the method of repair. In badly scored shafts the best repair is to have the work done on a grinding machine in a recognized machine shop. There are on the market certain tools for hand use which are reliable when used by an experienced mechanic.

If the damage to the shaft is of a minor nature the repair may be effected by means of a simple lapping or grinding tool made from two blocks of wood arranged to be clamped over the crank pin or journal in such manner as to secure even tension. That is, it would have to have provision for adjustment and some form of shim must be used to prevent it closing down on the low spots. A steel or cast iron lapping jig may be made up using the same precautions, or an old rod with its babbitt bearings, shim bolts and all complete may be used to do the work.

In normal service, a shaft wears gradually due to the fact that more pressure is exerted at certain points in its travel than at other points, as when receiving the power impulse, it is certain to wear out of round. This trouble will only develop after a great deal of normal service, and can be corrected as suggested above and in the job sheets.

Main Engine Bearings.—The function of the main engine bearings, or main bearings as the mechanic terms them, is to carry the

crank shaft in proper position and alignment at all times while permitting it to turn within them with the least possible amount of friction and loss of power, which is being transmitted through it to the transmission from the cylinders. These bearings are what is known as plain bearings in most cases. In certain types of engines ball or antifriction bearings are used, but they have never become popular for general use. The cause of this is likely difficult assembly, noise and lack of adjustment.

The main bearings are almost always of the split bushing type. They are composed of a white metal or babbitt bearing surface mounted in a bronze back or cast iron back, or in some cases directly in the engine frame and bearing caps. The bearing made up of the thin layer of metal sweated onto the harder metal has several advantages. It provides a greater amount of metal in direct contact with the shaft which serves to conduct the heat generated in the bearing away more readily. It is a well known fact that heat will not travel from one piece of metal to another as readily as it will travel and be dissipated within its own mass of metal. Witness this in heating a piece of metal in a fire. If there is a crack present it is shown up immediately due to the fact that on one side of the crack the metal may show a red, while on the other side the metal will still remain black. The metals may even lay so close that the eye cannot detect the crack until the change in color gives evidence of it. The larger the bearing, the more frictional heat will be dissipated by it and the less danger of that bearing being burned out.

Burned Bearings.—Bearings are burned for one reason only and that is lack of dissipation of heat generated within the bearing, or improper cooling of the bearing. Heat within a bearing is due to the friction of the rapidly moving or turning shaft sliding over the surface of the bearing metal. As an experiment the student should try rubbing his hands briskly together. The faster they are rubbed the warmer they become until they even become rather unpleasantly warm. Addition of pressure causes still more heat to be generated. This heat is due to friction. If soap and water are used between the palms while continuing the rubbing, the heat generated is barely noticeable. This is due to the fact that the soap and water form a good lubricant. Water only will relieve some of the friction, but not nearly so much of it as the application of soap and water. The water might be said to be a poor grade of lubricant. These liquids serve as lubricants because they prevent the hands from coming in contact with one another. The soap particularly serves to maintain a thin film of lubricant between the palms, thus preventing contact. The same condition exists in a well lubricated plain bearing. The shaft does not actually come in contact with the bearing metal, but rides on the oil film. Should it for any reason actually come in contact

with the bearing metal in a dry state disaster will follow in a few seconds. In this case the bearing is said to burn. The internal friction generated causes the metal to become heated, and if continued it will start to seize on the shaft in small particles and drag around with it. As the heat continues to develop it will become softer and softer and string out more and more, and even in extreme cases of burning will become so hot that it will melt and run out of the bearing and drop down into the crank case. Long before this happens there is usually evidence of trouble, although it may happen so quickly in the case of sudden failure of the oiling system, or exhaustion of the oil supply, that little warning or time is given.

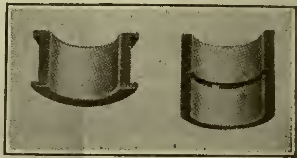


Fig. 139. Marmon Main Engine Bearing.

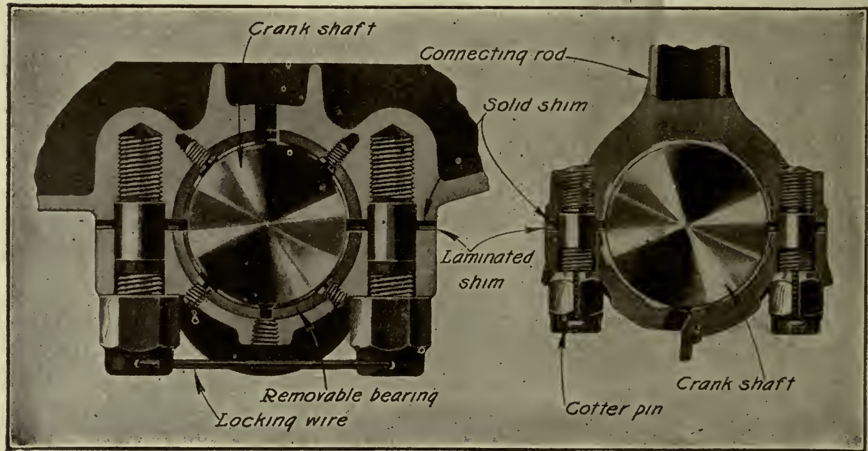


Fig. 140. Reo Crank Shaft and Rod Bearing.

While internal heat is the cause of bearings burning out, the cause of the heat may be due to several conditions. Failure of the lubricating system, poor quality of oil, excessive speed, hot weather, failure of the engine cooling system, foreign matter in the oil, and overload are the most common causes. There are varying degrees of burns from that in which the bearing metal is turned a blue black up to the point where the bearings seize, and the final point when the metal flows from the bearing. Babbitt melts at about 800 degrees. Depending on its alloys it may vary either way from this point.

Taking Up Main Bearings.—This is a necessity at intervals varying from a few thousand miles up to thirty, forty, or even fifty thousand miles of service, depending very largely and directly on the skill and care of the driver. Much depends also on the quality of

oil used. When this work is found necessary great care and good judgment must be used. Refer to Job 50.

Scraping in Main Bearings.—This is needed as a rule less often than taking them up. It is usually necessary only after years of normal service or when a bearing has been burned or otherwise abused. It is a tedious job and one requiring judgment, skill and patience. Naturally it is also expensive, as it is almost always necessary to remove the engine from the frame and rather completely dismantle it. Refer to Job. 51 for further directions.

Pistons.—The function of the piston is to draw in the gasoline and air on its downward stroke, compress this fuel charge on its upward stroke, receive the power as developed from the firing of the charge, transmit this power to the piston rod and crank shaft, and on its second up stroke free the cylinder from burned gases.

MATERIAL AND CONSTRUCTION

Piston.—Pistons are usually made from cast grey iron although many made of aluminum or aluminum alloy are used. One of the

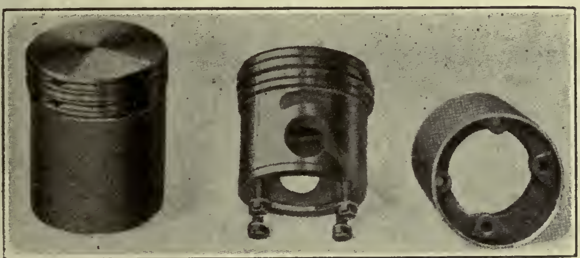


Fig. 141. Marmon 2-Piece Piston. At left, Piston Assembled. At Center, Aluminum Head and Body. At right, Iron Skirt.

developments of piston design is that of the Marmon where an iron sleeve is used over an aluminum body. This obviates all danger of piston pin scores. The two parts are assembled from the inside, using cap screws to hold the parts together. While aluminum pistons have a desirable quality of lightness, the expansion to which they are subject when heated is about twice that of the iron pistons. This feature contributes toward a noisy motor when cold, and loss of compression in cold winter months. Accordingly, cast iron pistons hold rather steadily in favor and are so designed, cast, and machined that the weight is not excessive and can be cared for in balancing up the crank shaft and fittings.

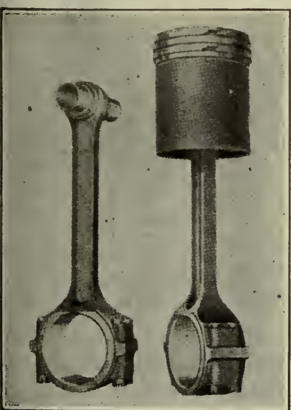


Fig. 142. Marmon Piston Rod Assembly.

Piston Clearance Allowance.—Ordinarily the mechanic does not turn down or machine pistons. However, he will need to understand allowances in fitting them and be able to judge clearance rather accurately. Special allowances are made in special cases, but a rule safe to follow in the regular routine of work is, for cast iron allow .00075″ at the skirt and .002″ at the lands of the piston for each inch in diameter of the piston. Double these amounts for aluminum.

Piston Rings.—The function of the piston ring is to seal the joint between the piston side and the cylinder walls at all times, so as to prevent loss of power by gases escaping down past the piston. At the same time they are required to prevent the oil from working up into the combustion chamber in excess quantities, or unburned gasoline working down.

The individually cast and machined ring made from grey iron is standard. There are two styles of plain ring with two types of joint. The step or bevel cut eccentric or concentric rings are what is known as plain type piston rings and are used in a large percentage of engines. The advantage of the eccentric ring lies in the fact that a more even tension is maintained over the entire circumference of the ring. It might be compared to the Indian's bow which had the thickest part where the greatest strain came in use and permitted of an even bending. In this case the groove in the piston for the ring must be deep enough at all points to accommodate the thickest section of the ring. This groove need not be so deep in the case of the concentric, but the pressure will not be so even in this case and breaks are very likely to occur at the point opposite the joint when applying it to or removing it from the piston. Designers are agreed that the greatest single trouble with a piston ring is the liability to loss of power through loss of gases past the piston ring joint or lap. To overcome this many types of so-called leak proof rings have been designed.

Fig. 143. Kelly Piston and Rod Assembly.

Leak Proof Rings.—Rings purporting to prevent leakage of gas past the piston, and particularly past the joint, are numerous. Many excellent designs and excellent rings may be found. Because the trade name of one of the oldest and best of this type of ring was "Leak Proof", mechanics have come to class all specially designed rings of more than one-piece construction leakproof rings. The main point desired is to prevent gas escaping past the ends or through the joint.

Two methods are used in attempting to obtain the desired result. Either some special form of lap is used, or the ring is made in two or three pieces, with the laps so arranged that there is little chance for leakage of gas through them.

Generally speaking, that ring is best which is best fitted to the cylinder wall and the piston ring grooves irrespective of the type of lap. Certain types of rings do give better results in certain motors granting workmanship is equal in each case.

Refer to job sheets for data on fitting rings.

Piston Pins.—The function of the piston pin is to hold the piston and the piston rod together and in proper relation. It forms a flexible joint with an oscillating movement which permits the proper movement of parts to transmit power from the cylinder to the crank shaft. Piston pins are made from a high grade of steel machined and hardened, after which they are ground to size. They are made to size within very close dimensions and can usually be obtained in oversizes which range from .001″, .002″, .003″, .005″, .0075″, .010″ oversize. The pins are usually made hollow because they must be made light, and at the same time have sufficient bearing surface to withstand tremendous hammering and pounding while carrying heavy loads.

Piston Pin Fit.—The piston is cast with bosses to carry the pin. Sometimes provision is made for bushing these. The pin fits into these bosses in a close manner, .001″ being sufficient clearance, unless the lubrication is force feed when .002″ to .003″ is allowed. This close fit is needed to prevent a piston pin knock as the piston, when it reaches upper or lower dead center, must be stopped and the direction of drive reversed. If there should be any perceptible play, the continual action of the piston on the pin would quickly result in sufficient wear to cause a knock to be heard. After this point is reached the wear is more rapid because the more the play the greater the force of the knock and consequently the more rapid the wear. Instead of a rotary movement the pin has an oscillating movement which results in uneven wear. This appears on the top and bottom of the pin and in the same points with reference to the piston pin bushings.

Securing the Piston Pin.—More badly scored cylinders result from loose piston pins than from any one other cause. A piston pin score is very difficult to repair, although it can be done by welding or filling in with certain metals. The block is usually replaced with a new one. To prevent scoring means that the pin must be so secured in the piston that it is impossible for it to work endways as it is the end of the pin projecting past the piston into the cylinder wall which causes piston pin scoring. Numerous methods of securing the pins in place are in use as the setscrew method, the dowel pin method, the bolt method, etc. Whichever method is used is also provided with some lock to prevent it working loose, and out.

Greatest care should be used to see that the fastening device, be it wire, washer, cotter key, or what not, is in first class condition. It is not a good plan to use many of these devices the second time as bending has weakened them.

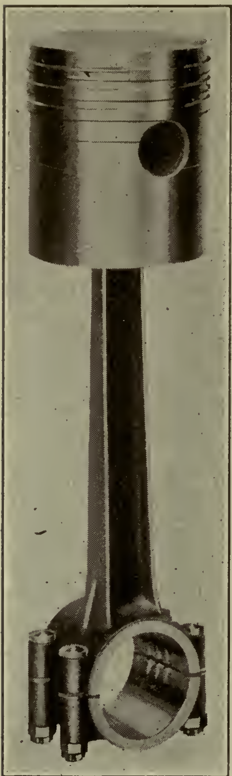


Fig. 144. Rochester Deusenberg Rod Assembly.

Connecting Rods.—The usual style of the connecting rod is H section drop forgings, although in the full force feed round hollow rods are used at times to facilitate oiling. In this case the oil is forced up through the center or hollow of the rod from the crank shaft to the piston pin. In case of full force feed oiling systems where the H section rod is used, a copper tube is run up on the outside of the rod to carry the oil. The drop forged type gains slightly in weight and strength from the piston toward the crank shaft. The function of the piston rod, or rod, as the mechanic calls it, is to convert the reciprocating motion of the piston into the revolving motion of the crank shaft, at the same time transmitting power from the piston to the shaft as on the power stroke, or from the shaft to the piston as on the compression stroke. It must be strong to resist end thrust, and light to prevent undue vibration.

Piston Pin Bearing.—The piston pin is carried in the upper end of the rod. At times the rod is designed to carry the piston pin bushing or bearing in the upper end. A close running fit is provided for the pin in the bushing, while a press fit is provided in the piston bosses for the piston pin ends. It is good practice where this type of construcion is used to secure one end of the pin only, leaving the other end free to expand when heated without distorting the piston.

More often, however, the pin is secured in the upper end of the rod and the bearings are in the piston bosses. Reference is made to this method in Job. 53.

Rod Bearings.—The lower end of the piston rod carries the rod bearings. This is of the split bushing type, also known as a "plain bearing". It is very similar to the main bearings. Adjusting and scraping of rod bearings is somewhat easier than that of the main bearings since they are more accessible and may be handled individually, and the fitting of one has no influence on any other as is the case in the main engine bearings. Rod bearings will be badly

worn or burned if run dry or even partially dry. A very disagreeable knock will develop in this case. The bearing should be adjusted immediately any evidence of wear is noticed.

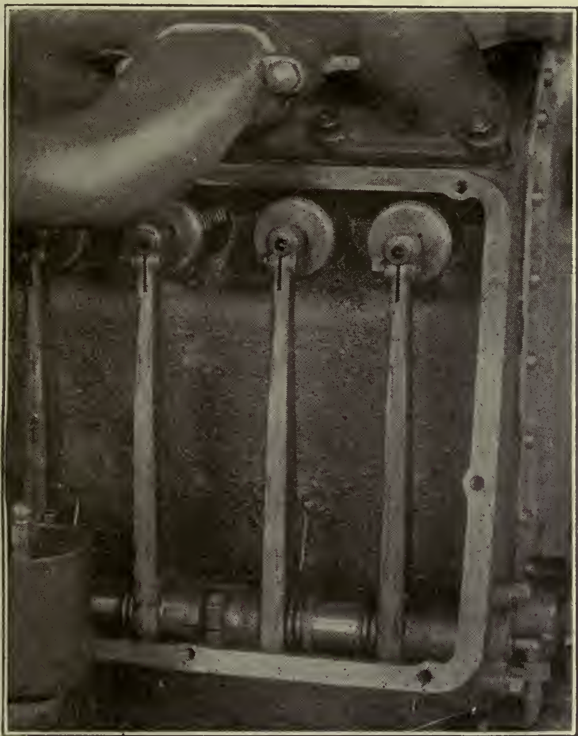


Fig. 145. Rochester Valve Mechanism.

Cam Shafts.—The function of the cam shaft is to open the valves at correct intervals of time, hold them open the correct length of

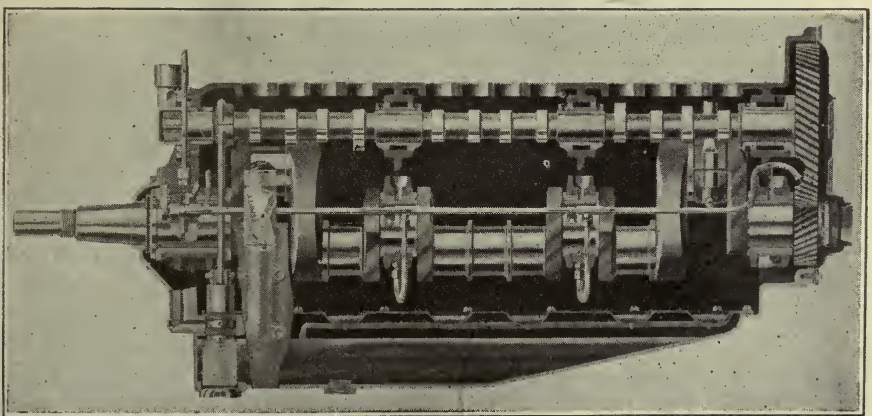


Fig. 146. Reo Cam Shaft and Related Parts.

time, and permit them to close at the correct moment. The design of the crank shaft must be taken into consideration in determining the firing order of the engine. The design of the crank shaft and the desired firing order of the engine are the determining factors in designing the cam shaft.

What the repairman needs to remember is that the firing order of any engine is fixed when the design of the cam and crank shaft

Fig. 147. Rochester Deusenberg Cam Shaft.

is determined on by the designer and manufacturer, and that thereafter there is only one firing order for that engine. If it is found necessary to determine the firing order of any engine, the action of the valve lifters as they raise and ride on the cams of the cam shaft will be the readiest source of information.

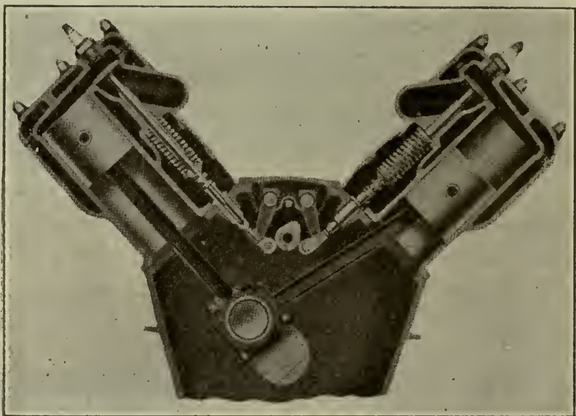


Fig. 148. Cadillac 8 Valves and Cam Shaft Arrangement.

Two Valves Per Cylinder.—Always, in the poppet type engine valve design, one valve is provided for intake and one for exhaust for each cylinder of the engine. In some cases four valves per cylinder are provided, two for intake and two for exhaust. Engines using four valves per cylinder are known as "dual valve" engines.

The intake valve opens on a down stroke of the piston in its respective cylinder, while the exhaust valve was open on the previous up stroke. For two strokes, or one revolution, or one-half cycle

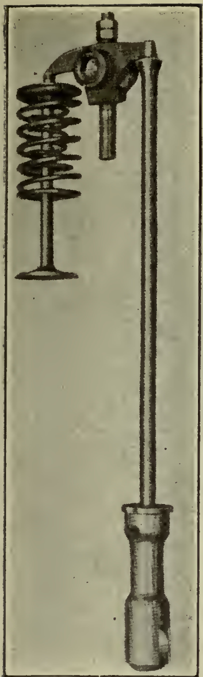


Fig. 149. Marmon Valve Mechanism.

neither valve is opened. This is during the compression stroke and the power stroke as they follow in succession after the intake stroke. The valves are actuated by the cams on the cam shaft which the engine timing gears hold in fixed relation to the crank shaft while driving it at one-half crank shaft speed.

In the operation of the valves, the valve lifter riding on the cam is caused to raise on the cam nose, thus raising the valve from its seat by pushing up on the bottom of the valve stem (in the case of an L or T head motor). The distance the valve raises off the seat is about 5/16″ to ⅜″. The length of time it is held open depends on the design of the cams.

Cam Shaft Drive.—Two methods, both positive, are in use for driving the cam shaft from the crank shaft. One is by the use of timing gears and the other by the use of the silent chain. In order that the correct speed relation or ratio be maintained at all times, it is necessary that the timing gear on the crank shaft have just one-half as many teeth as the timing gear on the cam shaft,

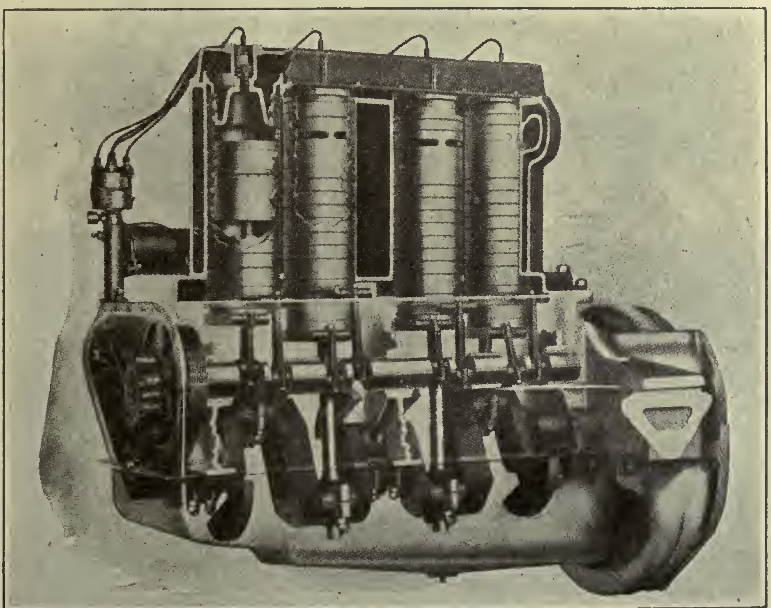


Fig. 150. Phantom photo of typical Stearns Knight motor, showing sleeve-valves and their operating mechanism.

thus giving a gear ratio of 2 to 1. The student will need to familiarize himself with the statement of the travel of the two shafts in degrees as, while the gear ratio is 2 to 1, the one travels through

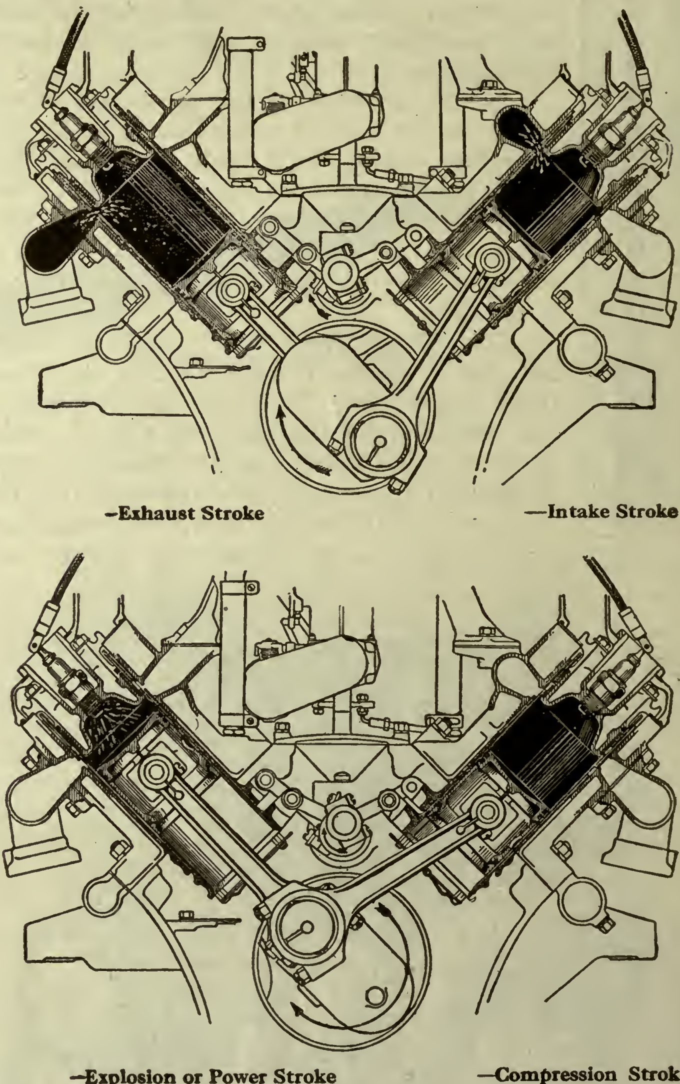


Fig. 151. Willys-Knight 8 Sleeve Valve Engine Section. Note position of parts in each stroke of the cycle.

only one half of a circle, or 180 degrees, while the other travels through a full circle, or 360 degrees. This is true of all four cycle engines and must be understood thoroughly by the student to grasp the actual theory and process of valve timing.

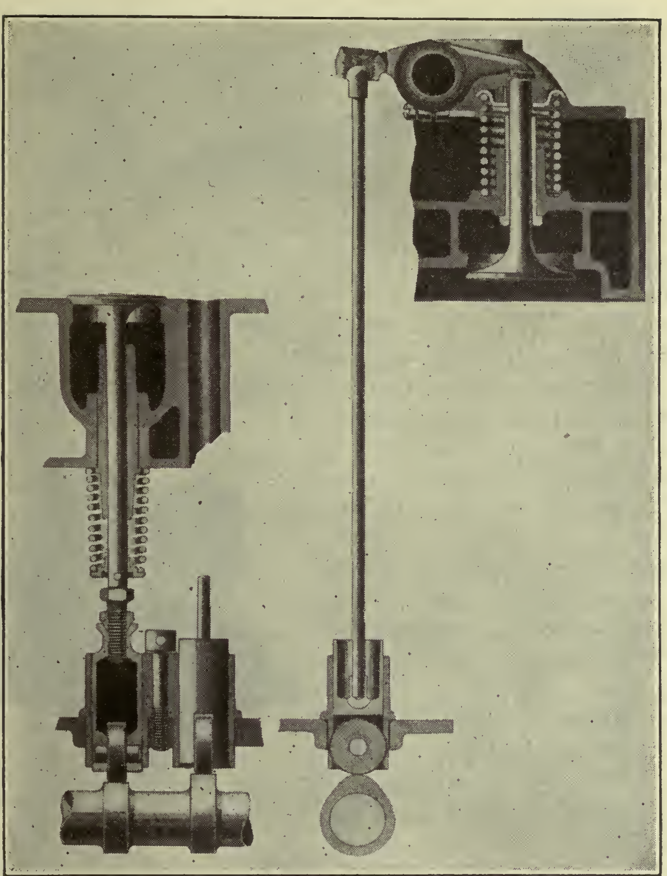


Fig. 152. Reo Valve Mechanism.

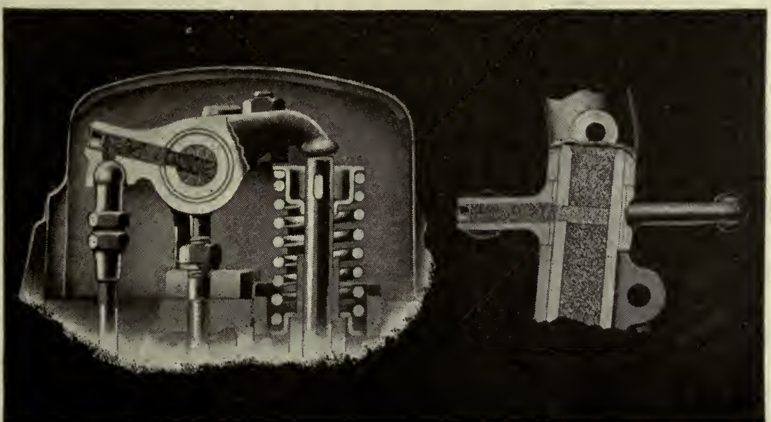


Fig. 153. Buick Self Lubricating Valve Mechanism.

Fig. 154. Reo Cam Shaft.

Valve Lifters.—Most valve lifters are made with a large seat or base to rest on the cam. This base is hardened to resist wear. The upper end of the lifter which rests immediately under the valve stem is provided with a screw for adjustment. This permits of setting the lifter to compensate for wear either within the lifter on the cam or the valve, as well as for expansion of the valve stem due to heat from the engine. Valve lifters seldom give any trouble except for a loose or bad adjustment.

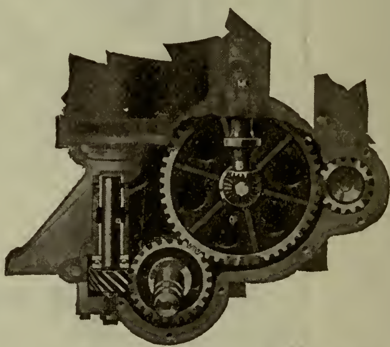


Fig. 155. Studebaker Bevel Timing Gears.

Valves.—The poppet type valve is in use in a very large percentage of the automotive equipment engines. Other styles of construction have at times proven successful, but in no instance have they been found to possess enough good features to offset the cheapness and desirable points of design of the poppet valve.

Valves are made from steel in one piece, and with a steel stem and cast iron, or other special head. Certain special steels as tungsten or nickel steel are used because of the fact that experience has shown that these metals will resist the high temperatures best. In some cases the inlet valves and the exhaust valves are made from different materials, each selected with a view to the conditions under which they do their work.

Valve Grinding.—Under service conditions a variety of causes result in valve wear which makes necessary the reseating of the valve on the valve seat. This is done either by grinding, or in cases of extreme wear, by the use of the reseating tools followed by grinding. Conditions contributing to valve trouble are the excessive heat which very often causes warping of the valve head. Constant action as it is dropped or forced onto the valve seat will cause uneven wear of the head. The constant rise and fall of the valve in the valve stem guides under strong spring pressure will cause uneven wear and ultimately result in improper seating of the head, as well as leaking

past the intake valve stems causing uneven operation of the motor. Carbon and heat will pit the valve seat. Carbon under the valve head will allow the flow of gases. All of these troubles contribute to a loss of power as the compression is imperfect and the power impulse loses force due to lack of compression and a loss of the exploded gases past the leaky valves. Invariably, or almost so, the intake valves require less attention than the exhaust. Several causes contribute to this. The intake valve deals with a clean cool mixture. The exhaust valve handles a flaming, hot, dirty, smoking, carbon depositing gas.

When the engine has been in operation a length of time sufficient to produce the results and conditions noted above, the valves are ground, valve lifters or tappets adjusted, and carbon removed, thus restoring to the motor its usual power. As to the actual need of valve grinding as opposed to the imaginary need of valve grinding much might be said. Because of the fact that valve grinding is comparatively simple it is one of the first things the amateur turns to. Some believe it a panacea for all engine ills. While it is true that leaky valves do cause much trouble, it is also true that carbon causes the leaking valves and a multitude of other ills which will be relieved and corrected by its removal. Valves may require reseating after 50 miles of service or after 50,000 miles of service. When they need the reseating they should have it. Frequent grinding wears away the head and the valve seat in the combustion chamber, making the actual point of contact wide and hard to maintain. As the valve head is made thinner and thinner it warps and burns more and more easily. Most valves are machined with the face of the seat at an angle of 45 degrees with the stem, although some are 60 degrees.

Rocker Arms.—In the case of the I head motor the valves are located over the cylinders in the head in an inverted position with reference to the valves in the L or T heads. This necessitates the introduction of a rocker arm mounted on the top of the head to receive the lift from the push rods resting on the valve lifters. The rocker arm receives this lift on its outer end, and as it rocks on its rocker pin it forces the inner end down on the upturned end of the valve stem, thus opening the valve. Valve timing is identical with the L head motor. This arrangement of valves is conceded by engineers to make a motor having in it a bit more power than any other construction. It is not as simple nor as sturdy a type of construction, as the number of small moving parts is greatly increased. The greatest difficulty is to keep these parts properly lubricated. Complete enclosure of parts has done much to correct lubricating faults.

Knight Type Engines.—One form of valve construction which has proven itself the equal of the poppet valve type, and even in

point of valve care a bit superior, is the Knight Sleeve Valve motor. The Stearns Knight, shown in Fig. 150, is typical of all Knight motors as all are made under the same Letters Patent. Instead of the piston being fitted into the cylinder, the cylinder is fitted with an outer and inner sleeve. The piston is fitted into the inner sleeve. The two sleeves are made a free sliding fit and in their upper ends ports are provided for the intake and exhaust mechanism. As will be noted in the cut, the sleeves are operated for short up and down strokes by means of eccentric rods worked from the eccentric shaft. This shaft takes the place of the usual cam shaft. At certain points in sleeve valve travel the intake ports are opened permitting a charge to enter. The ports are then closed and remain closed until after the compression and power strokes, when the movement of the valves or sleeves is so timed as to bring the exhaust ports or slots in line and permit the exhaust of the burned gases. Valve timing is identical with all four stroke cycle motors in that the eccentric shaft travels at one-half crank shaft speed, and the intake must be set to open at five to ten degrees past the top dead center.

Valve Timing.—The student has previously considered the four cycle principle. He has learned the various strokes. For theoretical purposes the stroke and operation were considered as identical. That is, the intake consumes exactly one stroke, or one-half revolution, and the compression, power, and exhaust each just one stroke or one-half revolution, or 180 degrees crank shaft or flywheel travel. Actually these operations vary considerably from 180 degrees, one-half revolution, or one stroke.

For instance, good practice does not open the intake valve on T. D. C., (Top Dead Center), but about ten degrees past T. D. C. in flywheel travel. This valve does not close at B. D. C., (Bottom Dead Center), but at about 35 degrees past B. D. C. This gives on an average about 205 degrees for intaking the fuel charge.

Fig. 156. Studebaker Valve Mechanism. Valves inclined at 20 degree angle. Bell Crank Lift.

From the time the intake valve closes to T. D. C., the cylinder is on the compression stroke or operation. This represents a distance of about 145 degrees of flywheel travel.

At the end of the compression stroke the charge is fired, the piston being forced downward. When the flywheel has traveled from T. D. C. to about 45 degrees from B. D. C., or through 135 degrees, the exhaust

valve is opened and remains open until B. D. C. has been reached and passed on up through the full 180 degrees to T. D. C., and to about five degrees past when it closes. In a few more degrees travel the cam shaft opens the inlet valve again. The power stroke is about 135 degrees long as measured in crank shaft or flywheel travel, the exhaust about 230 degrees, while the intake is 145 degrees, and the

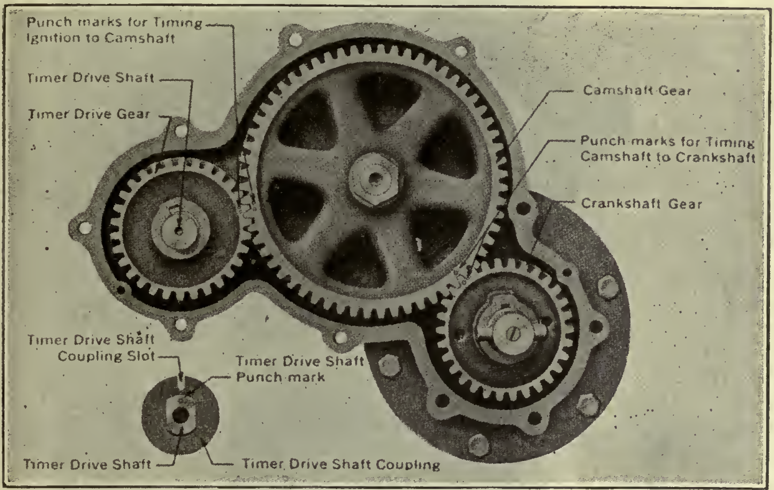


Fig. 157. Maxwell Timing Gears.

compression about 205 degrees. With a minus valve lap of five degrees added the sum of 720 degrees is obtained, which is equal to and represents two revolutions of crank shaft and flywheel, four strokes or operations, and one complete cycle. During this time the cam shaft has traveled through one complete revolution or 180 degrees. Each valve has been opened just once. The time the valves remain open is determined by the design of the nose of the cam, the exhaust cam having a broader nose than the intake cam. The time at which the valves open is determined by the setting of the cam shaft in relation to the crank shaft. Summarizing the above figures gives the following table which is representative of the average in valve timing and not of any specific engine:

1 revolution equals ½ cycle, equals 360 degrees travel.

2 revolutions equal 1 cycle, equals 720 degrees travel.

Intake, first quarter cycle or stroke equals.......	205 degrees travel
Compression, second quarter cycle or stroke equals	145 degrees travel
Power, third quarter cycle or stroke equals......	135 degrees travel
Exhaust, last quarter cycle or stroke equals.....	230 degrees travel
Minus valve lap, equals.........................	5 degrees travel
One completed cycle totals....................	720 degrees travel

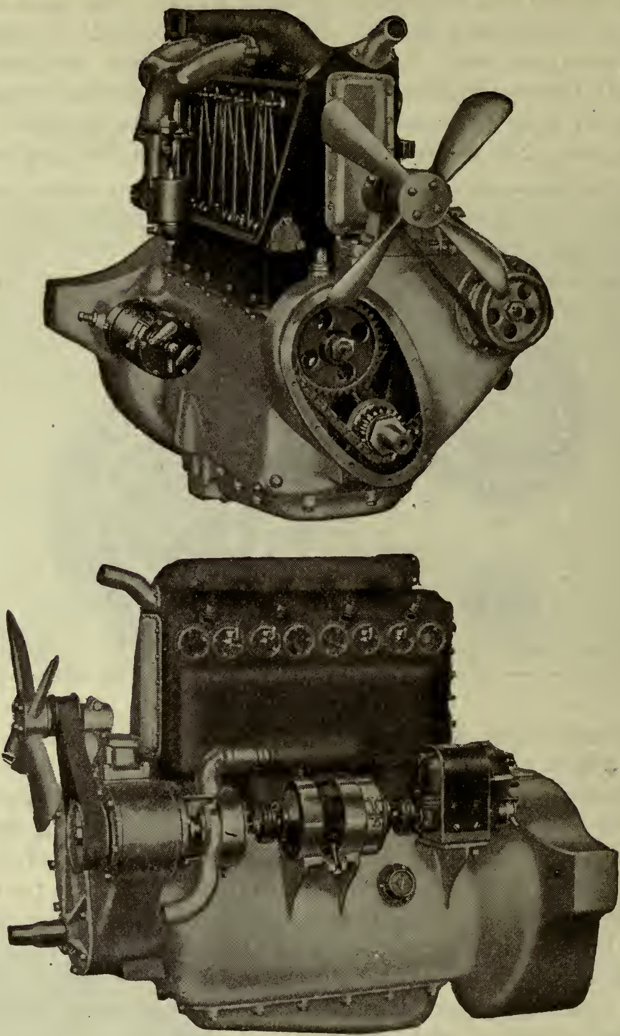


Fig. 158. Right and Left Side Views of Rochester Model G Deusenberg Type Engine. Bore 4¼", Stroke 6". Note Horizontal Valve Action.

Valve Lap.—This is the term applied to the condition of valve action with reference to the closing of the exhaust valve and opening of the intake valve. Either a plus or minus lap is possible. With a plus lap both are held open for a few degrees of flywheel travel at the same time. In rare cases this will be as much as from ten to twenty degrees. The minus lap rarely exceeds ten degrees and is more often less than five.

As stated previously, these figures are fairly representative of

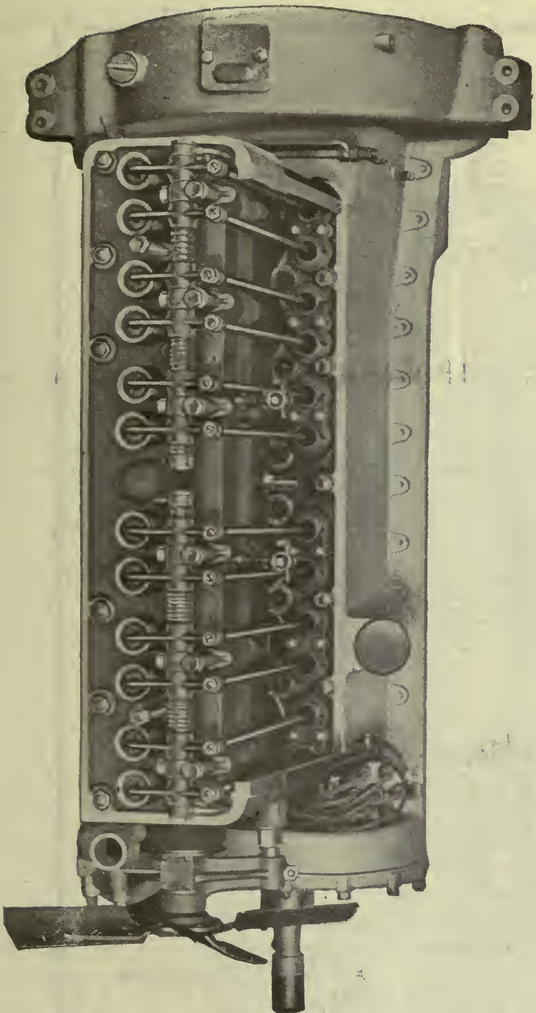


Fig. 159. National Valve Mechanism with the cover plates removed. Lubrication is effected through the hollow rocker arm shaft.

the general average. In actual valve timing where no mark is on gears, or old gears are being replaced with new ones, it need not be expected that every type of motor will correspond exactly to the figures given. In timing up some engines, especially those with coarse gear teeth, it would likely be impossible to more than approximate these figures. Since valve timing with respect to setting of the timing gears together is usually done with the exhaust valve just closing and the intake just opening, one tooth out of time either way would be so obvious that there would be little room for doubt as to when the exact teeth were in mesh to have the exhaust closing at about five degrees after T. D. C., and the intake opening about five degrees later. When timing any engine care must be used to have the piston in the cylinder being worked from, usually No. 1 on top dead center.

Another method of timing valves, quite as reliable as the one given above, is that given with reference to the timing of the Hudson Super-Six in Job 63. Here distance is measured by inches of piston travel as well as inches of flywheel travel.

Degrees Converted to Inches.—While it may be difficult to figure the number of degrees within a certain space on the flywheel by the use of a protractor, it is comparatively easy to find the number of degrees included in one inch of the flywheel circumference. With a tape line measure the distance around the flywheel and divide this into 360 degrees.

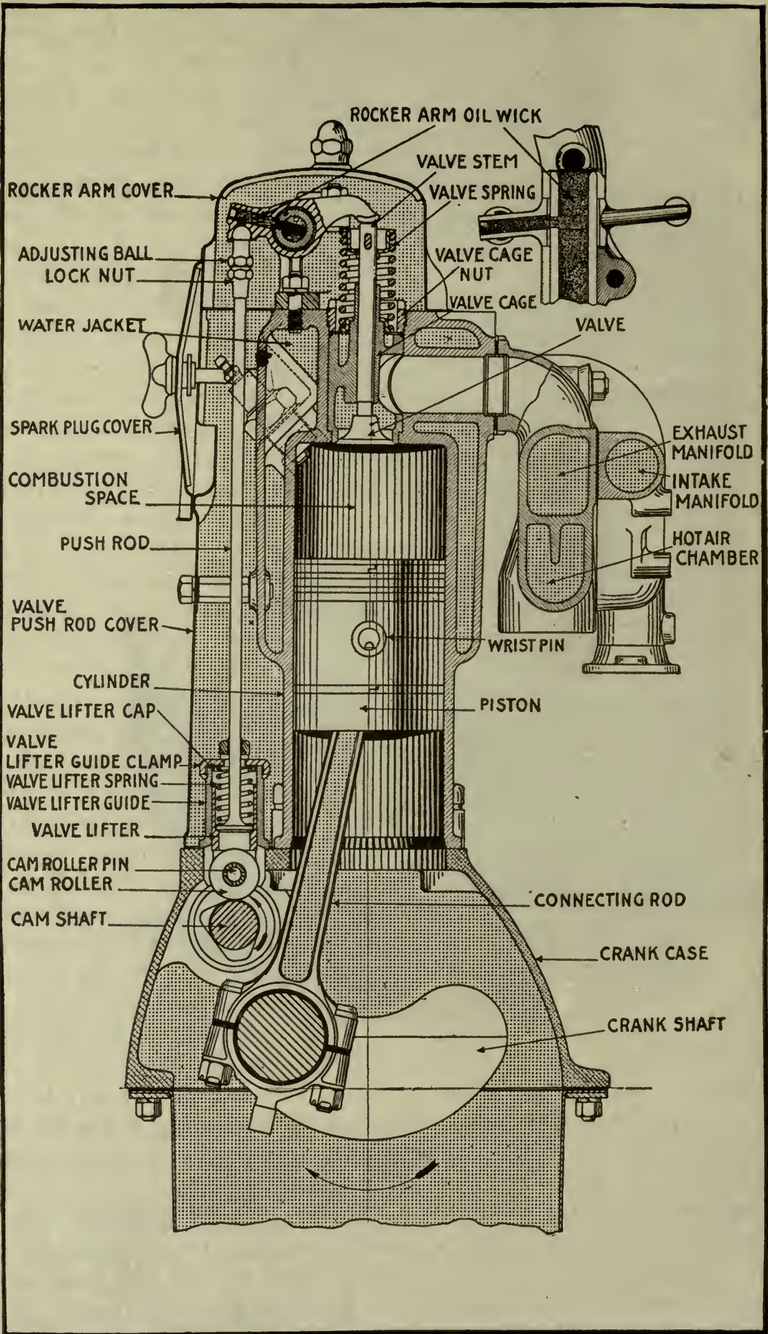


Fig. 160. Buick Valve Mechanism and related parts.

JOB 48. FITTING OR TAKING UP CONNECTING ROD BEARINGS

1. The following directions apply equally to the work whether it is done for practice or in actual service work.

2. Remove the rod from the crank shaft.

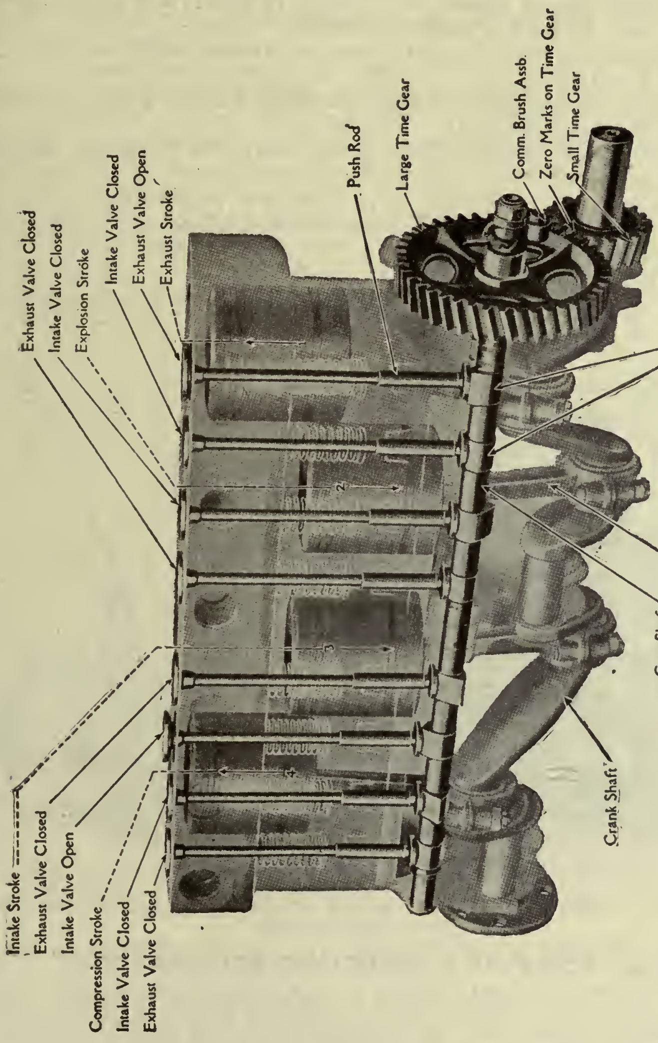


Fig. 161. Ford Cylinder Assembly, showing the correct position of the valves, with timing gears properly set according to punch marks on the gears, also the relative position of the pistons in their strokes as indicated above. Firing order 1-2-4-3.

3. Note how assembled so as to insure proper reassembly.
4. Learn also and note:
   a. Front end of crank shaft,
   b. How flywheel would be fastened,
   c. Cam shaft side,

d. Number of main bearings,
e. Number of throws on shaft,
f. Number of cylinders shaft would care for.

5. Adjusting a bearing.
   a. On removing the rod cap you note a number of shims are found.
   b. These should always be retained in order that on reassembly they go back in original position.
   c. Remove several thin shims and try reassembling the rod. Is it too tight?
   d. Keep adjusting shims until you have learned what too tight is. Have it inspected.
   e. Replace shims until you learn what too loose is. Have it inspected.
   f. Now adjust for proper fit as though it were to go into the car and you were the sole judge of correctness. Have it inspected and rated.
   g. Always be sure to place a coat of oil on the bearing on final assembly. To neglect this may burn out a bearing before the oil reaches it.

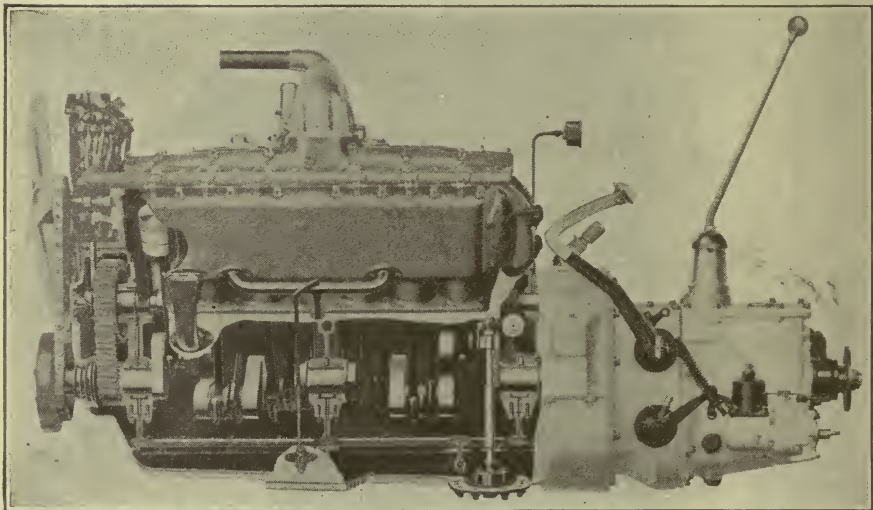


Fig. 162. Packard Engine. Note method of assembling rod bearings. Also size of main bearings.

JOB 49. SCRAPING CONNECTING ROD BEARINGS.

1. The following methods should be used whether the work is done with the shaft out of the engine or with the shaft in position in the engine. In the first case the piston must be maintained at right angles to the shaft.
2. Remove the rod cap and shims.
3. Treat the crank pin of the shaft with a thin coat of bearing blue.
4. Clamp the rod to the shaft having in the proper amount of shims.
5. Rotate the rod on the shaft for three or four turns.
6. Remove the rod.
7. Note bright spots on the bearing and take it to the instructor for explanation.

8. Secure a bearing scraper and with this remove the bright spots which are the high points.

9. Continue this operation until you have at least a 75 per cent bearing which will be indicated by the frequency or closeness of the spots. In a well fitted bearing the blue will appear evenly distributed over the bearing after fitting.

10. It may be necessary to remove or add shims in work of this nature from time to time.

11. When finally fitted, the weight of the piston on the rod should be sufficient to carry the rod slowly downward when started from the top, but not loose enough to oscillate back and forth. In fitting rods in an engine where this test cannot be made, a fair idea of their correctness may be secured by tapping the rod side to side with a hammer. A medium blow should cause it to move endwise on the crank pin. If it does not move, it is too tight. If it can be shoved with the hands it is too loose.

Caution: Enough shims must be used to hold the cap in the correct position when the nuts are drawn up tight. **Never** release nuts to get the right clearance. Always add shims and draw tight.

Bearing scrapers. Bearing scrapers must be kept sharp. A good India oil stone is best for this. Get your instructor to show you how to sharpen them.

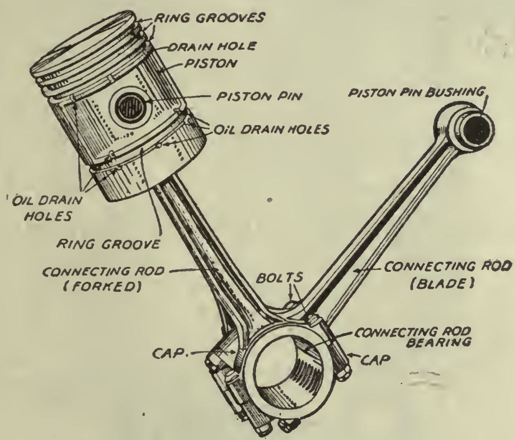


Fig. 163. Cole 8 Connecting rods are of the Yoked Type. The inner bearing is non-adjustable. When the play is too great these are replaced with new ones. The Blade rod is adjustable. Its bearings are fitted over the back of the inner bearing which is fastened to the yoked rod.

JOB 50. FITTING OR TAKING UP MAIN ENGINE BEARINGS.

1. Except in rare cases it is not advisable to attempt to scrape in bearings with the engine in the car frame. In the case of bearing adjustment where the bearings are worn loose, but are otherwise in good condition, the work is ordinarily done with the engine in the frame. In either case proceed as follows.

2. Remove bearing caps and shaft.
3. Clean, oil and reassemble.
4. Fit rear bearing first, by the adjustment of shims.
   a. Remove a thin one.
   b. Assemble and test.

c. Continue to adjust until proper tension or fit is obtained.
5. Remove or loosen cap on rear bearing.
6. Adjust center bearing.
7. Release center bearing cap.
8. Adjust front bearing.
9. Reassemble all caps using a coat of oil on the bearings.
10. Have each bearing when finished; inspected and final assembly inspected and rated.

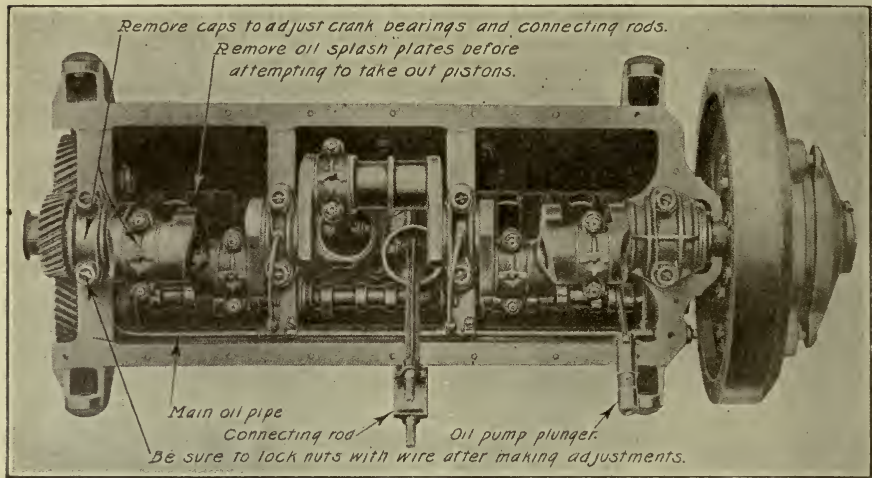


Fig. 164. Adjusting Rod and Main Bearings (Reo).

JOB 51. SCRAPING MAIN ENGINE BEARINGS.

1. It is the usual practice, in case bearings are in such condition that they need scraping, to remove the engine and place it in such a position that the work of scraping in the bearings is made accessible. Where a minimum amount of work is required the engine is sometimes left in the car frame. The

Fig. 165. Laminated Shims. Peel off a layer at a time in adjusting bearings.

engine should be removed from the car and placed in an advantageous position, after which the crank case should be removed so as to get at the bearings and shaft. The rods should also be removed.
2. Remove the bearing caps and clean free of all oil.
3. Apply a thin even coat of bearing blue to each crank shaft bearing, but not to the crank shaft bearing bushing.
4. Place the shaft in position in the case.
5. Rotate or turn the shaft three or four times.
6. Remove and scrape off the high points on bearing bushings.

7. Repeat the operation until all bearings are properly spotted in. At least a 75 per cent bearing surface should be obtained, otherwise the life of the bearing will be greatly shortened.

8. Extreme care and considerable time are required on this job.

9. Metal should be removed by very careful scraping. Do you know what .001″ is? This paper is .003″ thick. It might be written 3/1000. In scraping, metal should not be removed by thousandths of inches but rather by one-eighth of thousandths, or one-fourth of thousandths. That is, to remove an amount

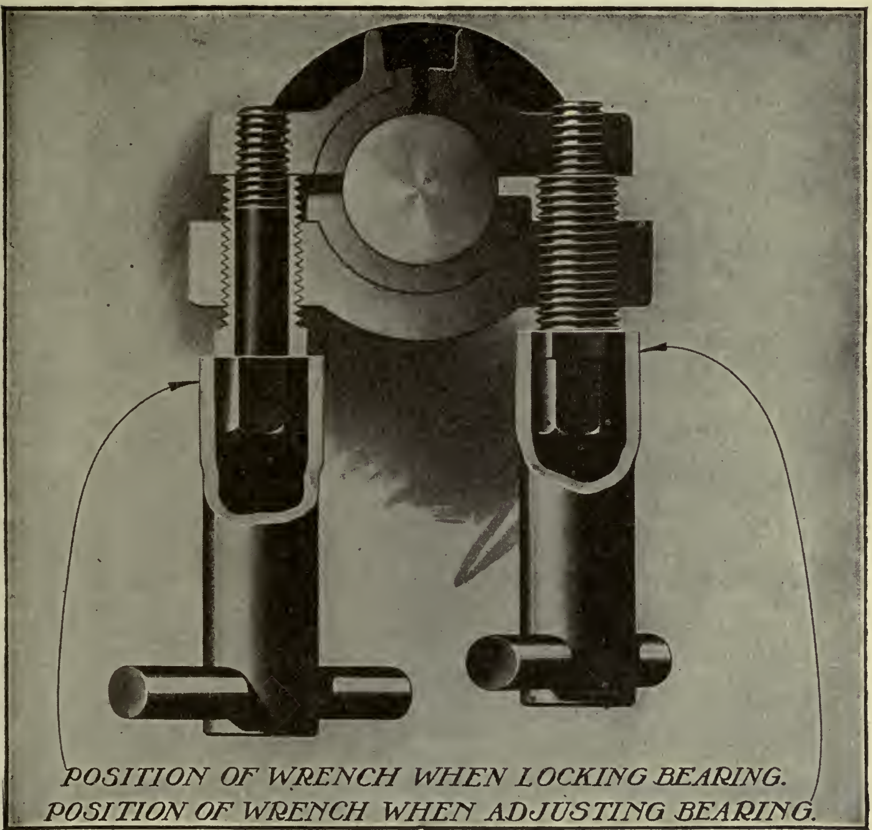


Fig. 166. Adjusting Main Engine Bearings, Earlier Models (Reo).

of metal, the thickness of this paper would require from 25 to 50 cuts of the scraper.

10. Be patient and observant on your first bearing work. All speed that is possible on work of this nature will come to you later.

11. What may happen if too much metal is removed from the front bearing?

12. What may happen if all new bearings of greater than original thickness are fitted?

13. Having the shaft properly fitted or aligned in the crank case, the bearing caps may be fitted.

14. a. Draw the end ones to hold the shaft in place.
    b. Work the center bearing to a fit.
    c. Slack the nuts on the center bearing a trifle.
    d. Fit the rear main bearing.
    e. Fit the front main bearing.
    f. Have each step inspected as you work.
    g. See that all oil grooves are cared for.
15. Have final assembly carefully oiled and keyed with cotter keys.
16. Have it inspected and rated.

JOB 52. POLISHING A CRANK SHAFT.

In use a crank shaft will frequently be worn so that grooves and ridges show, or are noticeable to the finger tips as they are run over the shaft bearing. In other words, it is scored. The score marks must be removed by one method or other before a bearing can be properly fitted. Having them removed and the shaft trued up it may be polished by one of several methods. As good a method as any is the following:

1. Wrap a piece of emery cloth a little narrower than the bearing around the shaft bearing.

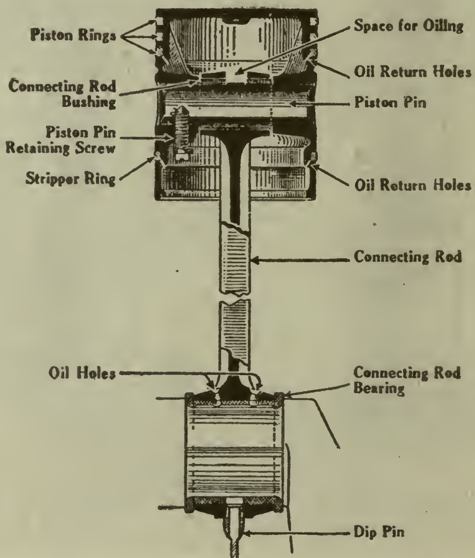


Fig. 167. Overland Piston and Rod with names of parts.

2. Take a light rope or heavy cord and give a number of turns around the cloth.

3. Draw this back and forth having one end in either hand.

4. Continue this until the shaft has a good bright polish.

5. Care must be used to see that emery cloth moves from side to side as well as round and round.

6. Oil may be used on the cloth if desired, but this is likely to loosen some of the grains of emery from the cloth. If this happens the shaft may be scratched. In any event, great care must be used to insure a good polish.

JOB 53. REMOVING A PISTON PIN OF THE CLAMP TYPE.

1. Where the clamp type of piston pin is used, the pin is clamped in the rod and the bushings which constitute the bearings are in the piston pin bosses.
2. Learn how the piston pin is secured.
3. Free the pin by loosening the clamp fastener.
4. Remove the pin by driving on the end of it with a hammer and a soft punch. Either hold the piston on the knees while the operator is seated on the bench, or set the piston on its head on the bench and drift out the pin while holding the piston in the crook of the arm. To press out a piston pin without a special form of press is very dangerous as the piston is very often pressed out of round, and in some cases is injured beyond repair.
5. Note the position of the bearing. Is this arrangement always used? What other arrangement might be used?

JOB 53A. REMOVING A PISTON PIN WHERE THE BUSHING IS IN THE ROD.

1. Make an inspection to learn the method of securing the pin.
2. Loosen the pin fastener which will be found in the piston pin boss.
3. Remove the pin by driving with a punch having the piston resting on the knees of the operator while he is seated on a bench, or set the piston on the head on the bench and hold with the arm while driving against the pin. To press out is very dangerous as the piston is very often pressed out of round.
4. Note where the bearing is. Is this arrangement always used? Could it be elsewhere?

JOB 54. REMOVING PISTON PIN BUSHING FROM PISTON.

1. This is work which requires good judgment on the part of the operator, or mechanic. Unless extreme care is used the piston may be ruined.
2. Secure a drift of a slightly smaller diameter than the outside of the bushing.
3. Hold between the knees while seated on a bench and drive the bushing into the piston.
4. In replacing a bushing, or putting in a new one, first file the burr from the ends on a taper **not over 1/16″ long.** Start true and drive in, using a wood block.
5. In removing a bushing from a rod set the new bushing on the old and press the old one out and the new one in. Be careful of burrs.

JOB 55. FITTING MAIN ENGINE OR CRANK SHAFT BEARINGS ON FORD ENGINE.

1. After the engine has been taken out of the car, remove the crank case, transmission cover, cylinder head, pistons, connecting rods, and transmission and magneto coils. Take off the three babbitted caps and clean the bearing surfaces with gasoline. Apply bearing blue to the crank shaft bearing surfaces which will enable you, in fitting the caps, to determine whether a perfect bearing surface is obtained.
2. Place the rear cap in position and tighten it up as much as possible without stripping the bolt threads. When the bearing has been properly fitted, the crank shaft will permit moving with one hand. If the crank shaft cannot be turned with one hand, the contact between the bearing surfaces is evidently too close and the cap requires shimming up, one or two brass liners usually being sufficient. In case the crank shaft moves too easily with one hand, the

shims should be removed or the steel surface of the cap filed off, permitting it to set closer.

3. After removing the cap, observe whether the blue "spottings" indicate a full bearing the length of the cap. If "spottings" do not show a true bearing, the babbitt should be scraped and the cap refitted until the proper results are obtained.

4. Lay the rear cap aside and proceed to adjust the center bearing in the same manner. Repeat the operation with the front bearing, with the other two bearings set aside.

5. When the proper adjustment of each bearing has been obtained, clean the babbitt surface carefully and place a little lubricating oil on the bearings, also on the crank shaft; then draw the caps up as closely as possible, the necessary shims, of course, being in place. Do not be afraid of getting the cap bolts too tight, as the shim under the cap and the oil between the bearing surfaces will prevent the metal being drawn into too close contact. If oil is not put on the bearing surfaces, the babbitt is likely to cut out when the motor is started up before the oil in the crank case can get into the bearing. In replacing the crank case and transmission cover on the motor, it is advisable to use a new set of felt gaskets to prevent oil leaks.

JOB 56. REMOVING ENGINE FROM FORD CAR.

1. Drain the water out of the radiator and disconnect the radiator hose.

2. Disconnect the radiator stay rod which holds it to the dash.

3. Take out the two bolts which fasten the radiator to the frame and take the radiator off.

4. Disconnect the dash at the two supporting brackets which rest on the frame.

5. Loosen the steering post bracket fastened to the frame, when the dash and steering gear may be removed as one assembly, the wires first having been disconnected.

6. Take out the bolts holding the front radius rods in the socket underneath the crank case.

7. Remove the four bolts at the universal joint.

8. Remove the pans on either side of the cylinder casting, turn off the gasoline, and disconnect the feed pipe from the carburetor.

9. Disconnect the exhaust manifold from the exhaust pipe by unscrewing the large brass pack nut.

10. Take out the two cap screws which hold the crank case to the front frame.

11. Remove the bolts which hold the crank case arms to the frame at the side. Then pass a rope through the opening between the two middle cylinders and tie it in a loose knot. Through the rope pass a "2x4", or a stout iron pipe about ten feet long, and let a man hold each end. Let a third man take hold of the starting crank handle, when the whole power plant can be lifted from the car to the work bench for adjustment.

JOB 57. ADJUSTING CONNECTING ROD BEARINGS ON FORD ENGINE.

1. Drain off the oil.

2. Remove the plate on the bottom of the crank case, exposing the connecting rods.

3. Take off the first connecting rod cap and draw-file the ends a very little at a time.

4. Replace the cap, being careful to see that punch marks correspond, and tighten the bolts until it fits the shaft snugly.

5. Test the tightness of the bearing by turning the engine over by the starting handle. Experienced mechanics usually determine when the bearing is properly fitted by lightly tapping each side of the cap with a hammer.

6. Loosen the bearing and proceed to fit the other bearings in the same manner.

7. After each bearing has been properly fitted and tested, tighten the cap bolts and the work is finished. Remember there is a possibility of getting the bearings too tight, and under such conditions the babbitt is likely to cut out quickly, unless precaution is taken to run the motor slowly at the start. A good plan after adjusting the bearings is to jack up the rear wheels and let the motor run slowly for about two hours, keeping it well supplied with water and oil, before taking it out on the road.

JOB 58. ADJUSTING VALVE TAPPETS.

It is possible to set the tappets on the modern engine up so close as to make them noiseless in practically every case. This, however, is not good practice. While it may please the operator and owner temporarily, in the end it is certain to be the poorest sort of economy. It is generally conceded and known that the heat of the engine is sufficient to cause the valve stems to expand quite a bit over their length when cold. The result is that when they are hot the cam and cam shaft will have to bear the weight of the explosion on the top of the valve since it will not quite close onto its seat. This load, which is considerable, may also result in the springing of the valve stem. It also contributes to cut and worn tappet faces and cams. Because of the fact that the valve does not quite seat there is always a loss of compression past it which causes the face of it to be burned very quickly. Valves were designed

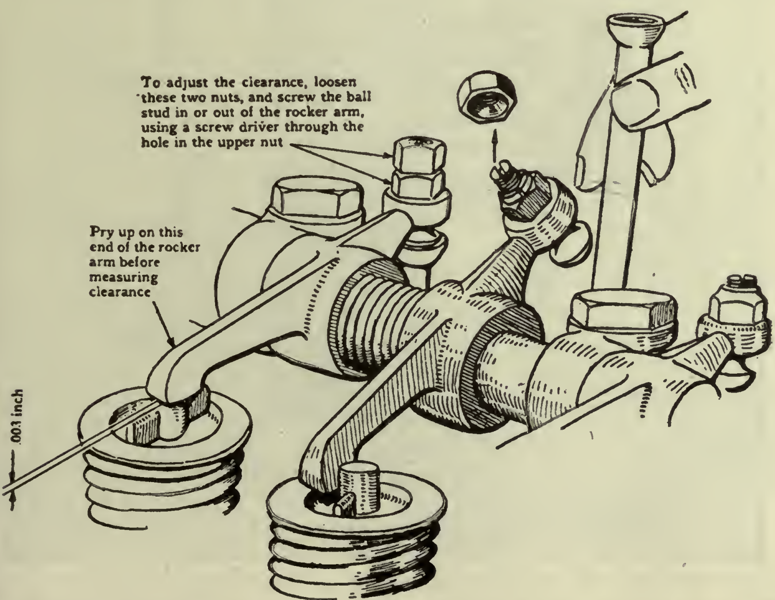


Fig. 168. Adjusting Valve Clearance on Overhead Valves (National Sextet).

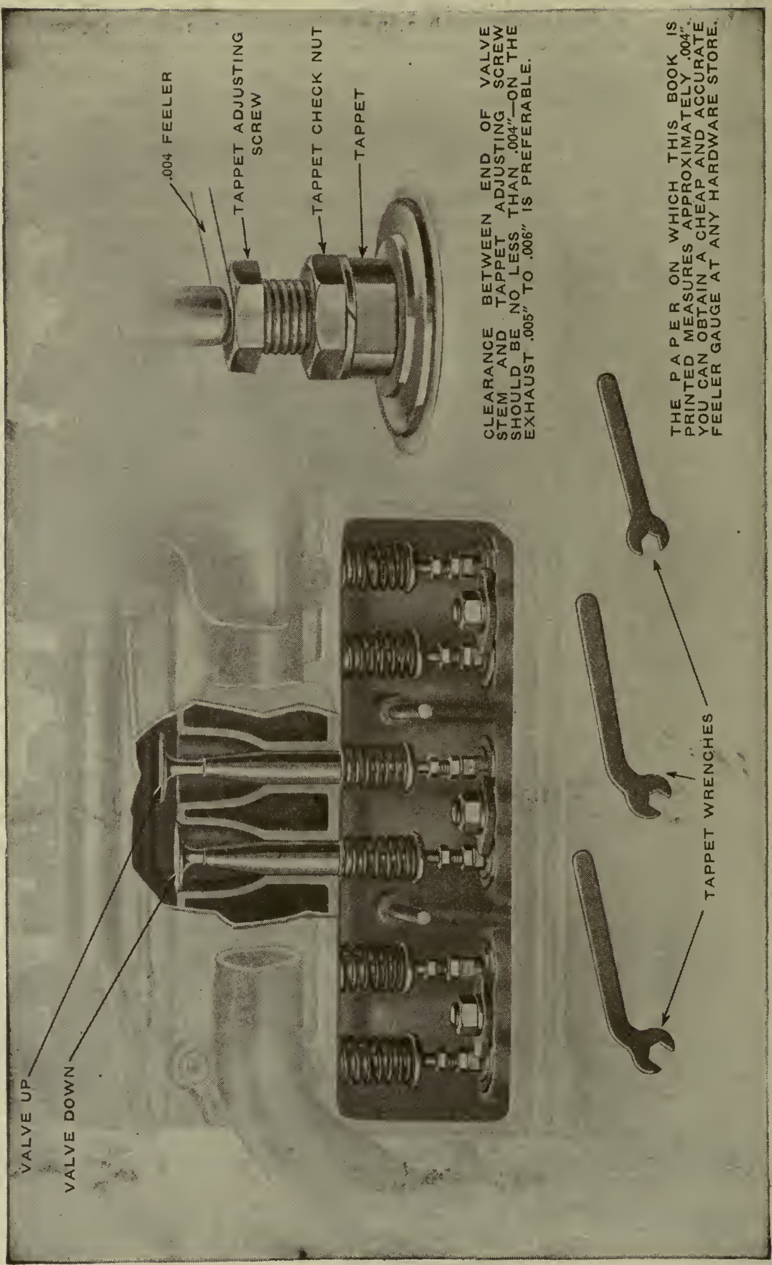


Fig. 169. Adjusting Valve Tappets (Hudson Engine).

to close tightly and enough clearance between the tappets and the lower end of the valve stem must be allowed that the expansion of the stem due to heat will not be great enough to overcome the allowance. To prevent an aggravating noise set them all alike. Do not depend on feel of the play, but rather upon the feeler or thickness gauge. Allow .004" to .006" clearance.

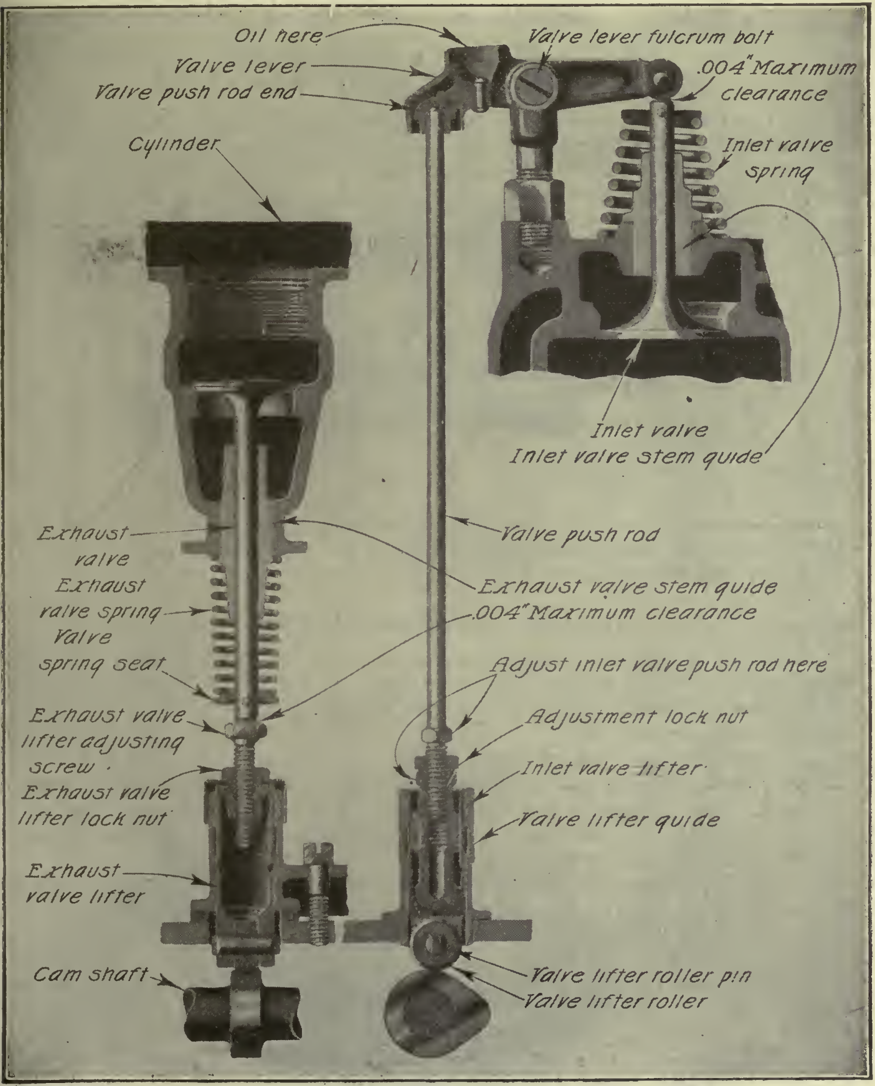


Fig. 170. Reo F Head Valve Operating Mechanism.

1. To adjust tappets the engine should be put in the same position as for grinding valves, that is, on compression stroke for the cylinder to which the tappets belong.

2. With a thickness or feeler gauge test the clearance between the top of the tappet adjusting screw and the bottom of the valve stem.

3. The amount of clearance should be adjusted to .004″ for intake and .006″ for exhaust or that recommended by the manufacturer of the particular engine being repaired.

4. Why is this amount of clearance not the same in all cases?

5. In the case of tappets not adjustable the valve stem will need to be filed if it is too close.

JOB 59. METHODS OF REMOVING VALVES.

As the student is already aware, the position of the valves in the engine is not always the same. Neither is the method of securing them in position just the same in every case. The usual method of holding the spring in place is to put a cupped washer under the spring, and under the washer either a horse shoe retainer or a pin. In rare cases the valve adjustment is on the lower end of the valve stem and the spring and washer are thus retained.

1. Learn the best method of getting at the valves.
   a. Remove valve covers.
   b. Remove port plugs.
   c. Remove head.
2. Having valves accessible, next proceed to remove them.
   a. Fit on a valve lifter.
   b. Release tension on pin or retainer by compressing spring.
   c. Release spring.
   d. Remove valve lifter.
   e. Remove valve.
   f. Inspect for marking. If not marked be certain to do so at once, otherwise the valves will become mixed and much trouble will result.
3. In this manner remove all valves.

JOB 60. CLEANING VALVES.

After the valves have been removed from the engine, the next step is to clean them free of all carbon accumulations. At times, too, there will be rust on the stem, particularly where the oiling system has failed. Several methods are in use for cleaning them.

1. Scrape the carbon off with a knife.
2. Polish the head and stem with fine emery cloth. This may be done.
   a. Bore a hole in a board that will be a snug fit for the valve stem. Hold the board in a vise and polish by running a strip of emery around the valve and the stem.
   b. Hold the valve in a portable drill or breast drill chuck. Polish while turning by holding the emery cloth against the valve.
   c. Hold the valve in the drill press or lathe chuck and polish.
   d. Polish by hand.
3. Kerosene is often of aid in removing carbon deposits and gummed oil.

JOB 61. GRINDING VALVES.

The following directions apply equally well to all types of cars, excepting to those of the removable valve cage construction. In that case the cages are removed and the end of the valve stem is gripped in the vise, after which the cage is rotated on the valve in much the same manner as the following process where the valve is rotated.

1. Secure a valve grinding tool and some compound.

2. Place a little valve grinding compound on the valve face, using the finger to distribute it.

3. Place the valve in the engine until it rests on the valve seat.

4. Have the piston for cylinder No. 1 on T. D. C. compression stroke. This may be obtained by turning the engine by hand until both the exhaust and intake valves are seen to work one following the other closely and then one-half turn farther.

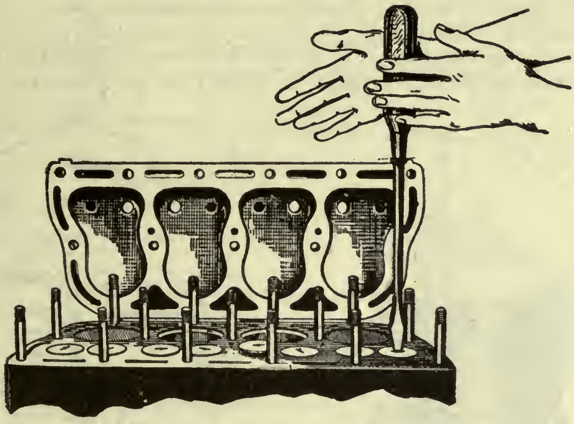


Fig. 171. Grinding Valves Using a Screw Driver as a valve grinding tool (Overland).

5. With the grinding tool turn the valve about three-fourths turn around and then reverse, at the same time applying a light even pressure.

6. Start with a coarse or medium compound depending on the condition of the valves.

7. Continue until all pits are removed, then finish and polish with fine compound.

8. Considerable patience is required in this work. A light coil spring placed under the valve head will facilitate its removal. Also help to speed up the grinding as it can be depended on to raise the valve and let it be reseated quickly at another point.

9. Have the job inspected as you progress and when the first valve is finished.

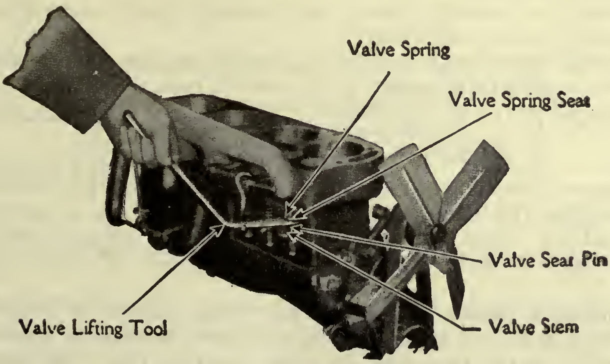


Fig. 172. Lifting Valve Springs (Ford).

10. When all are finished the work should be rated.

11. When reassembled it will be found necessary to test all valve tappets and have them adjusted when necessary.

JOB 62. RESEATING VALVES.

In cases where the valves have been ground a number of times and show a considerable shoulder it will be necessary to reseat them to secure a good job, otherwise the seating face grows too wide and the valve is also liable to hang on the shoulder in its face. A number of good sets of tools are on the market which may be used for this work. The sets consist of a tool used for refacing the valve itself and a separate tool which is used to ream out the valve seat. In some cases the valve port wall is reamed out to permit of a so-called hair line contact of the valve on its seat.

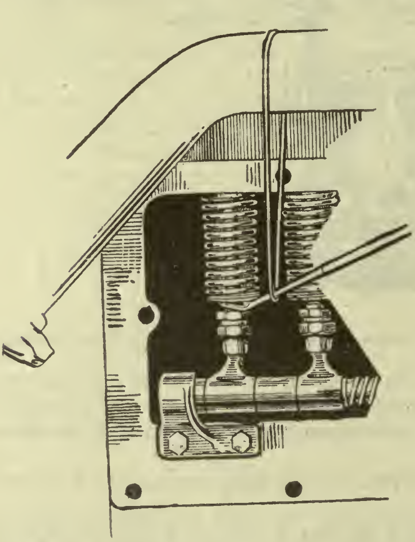


Fig. 173. Lifting Valve Springs (Overland).

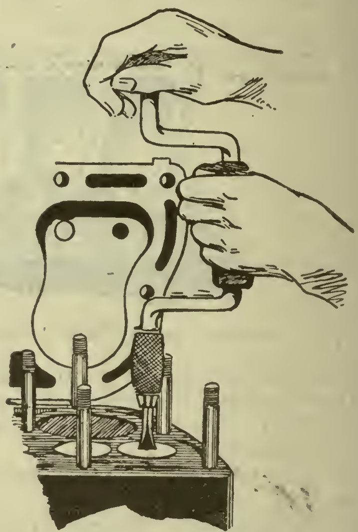


Fig. 174. Grinding Valves.

1. Re-face the valve first by carefully setting it up in the tool, taking just a light cut from its face.

2. Reseat the valve by using the reaming cutter properly fitted to the cylinder casting in the valve port.

3. In either case use a firm even pressure, and do not remove any more metal than is necessary to secure a true seat or face.

4. Grind as in Job 61 to finish.

JOB 63. TIMING ENGINES.

The student having studied the previous instruction given in this chapter on valve timing will be in a position to understand the actual operation as explained below. These instructions will apply in a general way to any job of valve timing. A number of charts representative of general practice are given.

1. Ordinarily timing gears, whether chain driven or gear driven, are marked, but this is not always the case. After the timing gears have been exposed, which means removing the plate covering them, the next step is to inspect the gears for timing marks.

2. If no marks are present, the mechanic will do well to place some after first setting the engine in timing position.

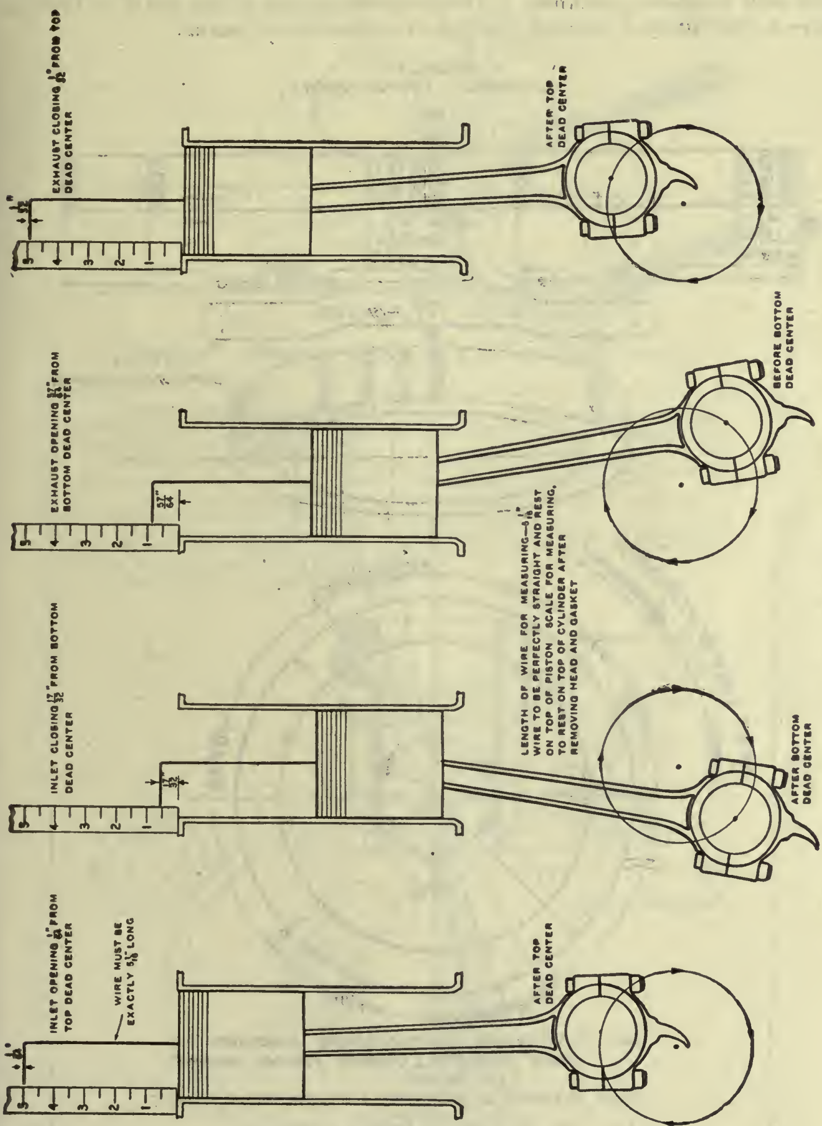


Fig. 175. Hudson Super-Six Valve Timing Measured by Piston Travel.

3. The parts may now be disassembled to allow for any replacement and repairs.

4. When replacing the timing gears the cam shaft must be replaced in proper position as well as the crank shaft and pistons, after which the gears may be replaced.

5. Where new gears are to be placed in the engine it is possible to transfer the marks from the old. However, in such case the engine should be timed with complete exactness to check up the setting of the gears as there is always a possibility of making a mistake in transferring marks.

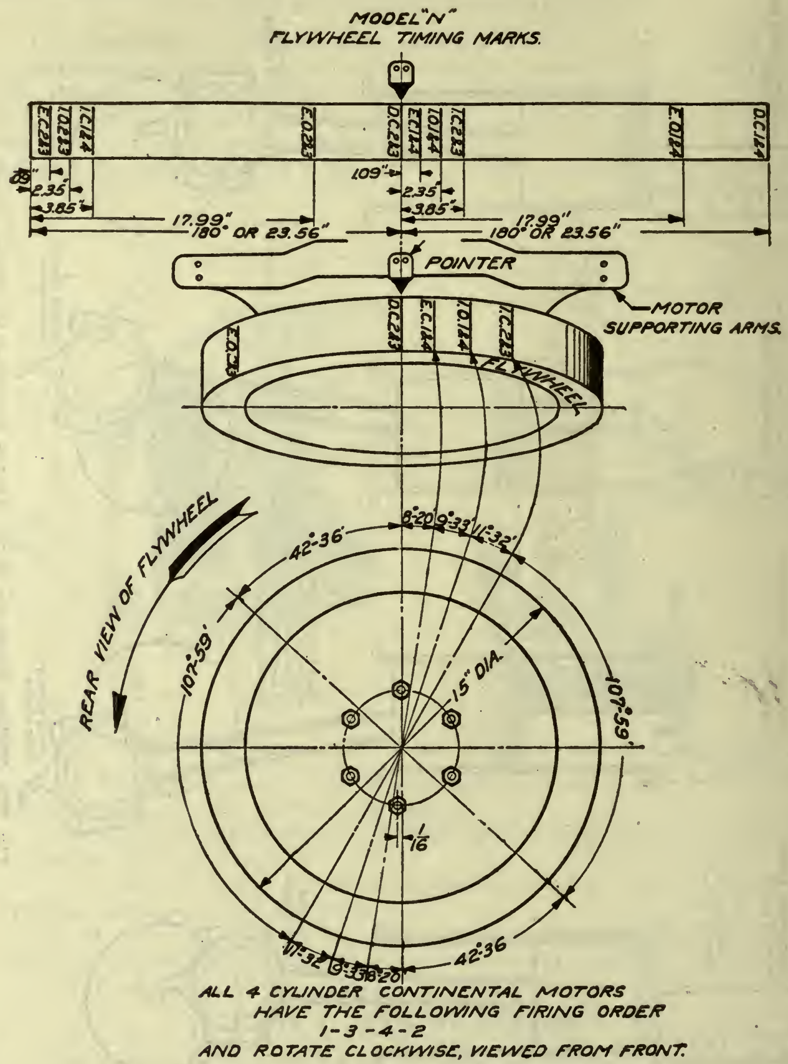


Fig. 176. Continental 4 Engine Timing.

6. In all cases of engine timing the real proof of exactness is not the marks on the gears, but the position of the crank shaft and piston assembly in relation to the cam shaft, valve tappets and valves. This proper relation has been explained at an earlier point in the chapter.

7. Never attempt to check up the engine timing until the valve tappets have been properly set. Too great a clearance in the tappet adjustment will

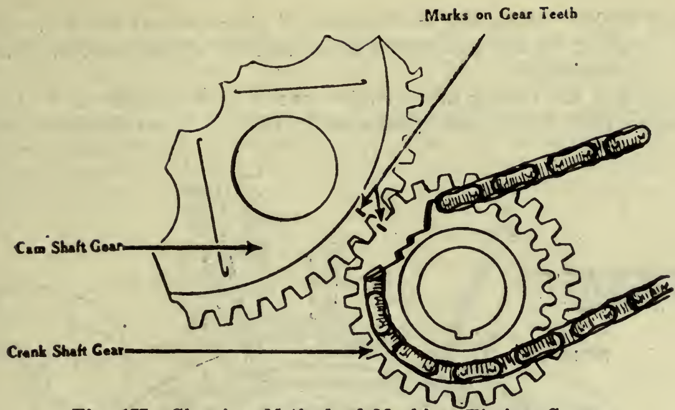


Fig. 177. Showing Method of Marking Timing Gears.

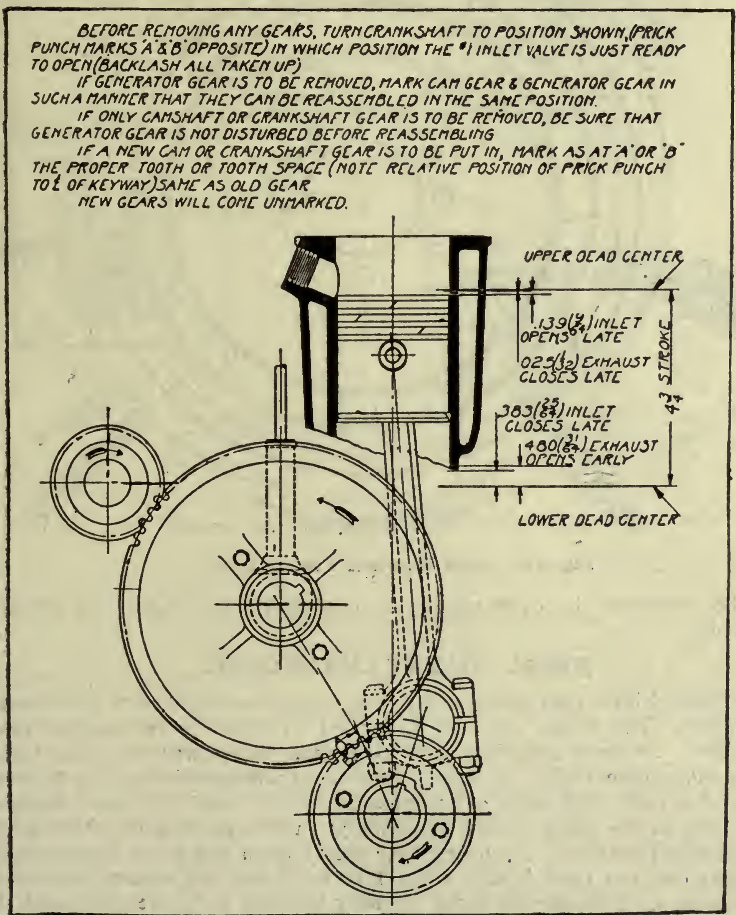


Fig. 178. Setting Timing Gears.

make a very decided difference in the point of piston travel at which the valve will open. Neglect of this point may cause serious trouble and even retiming when it is not necessary.

8. As a rule, the timing of an engine needs little thought as it is fixed in such a manner that there is no chance of it failing. However, too much care

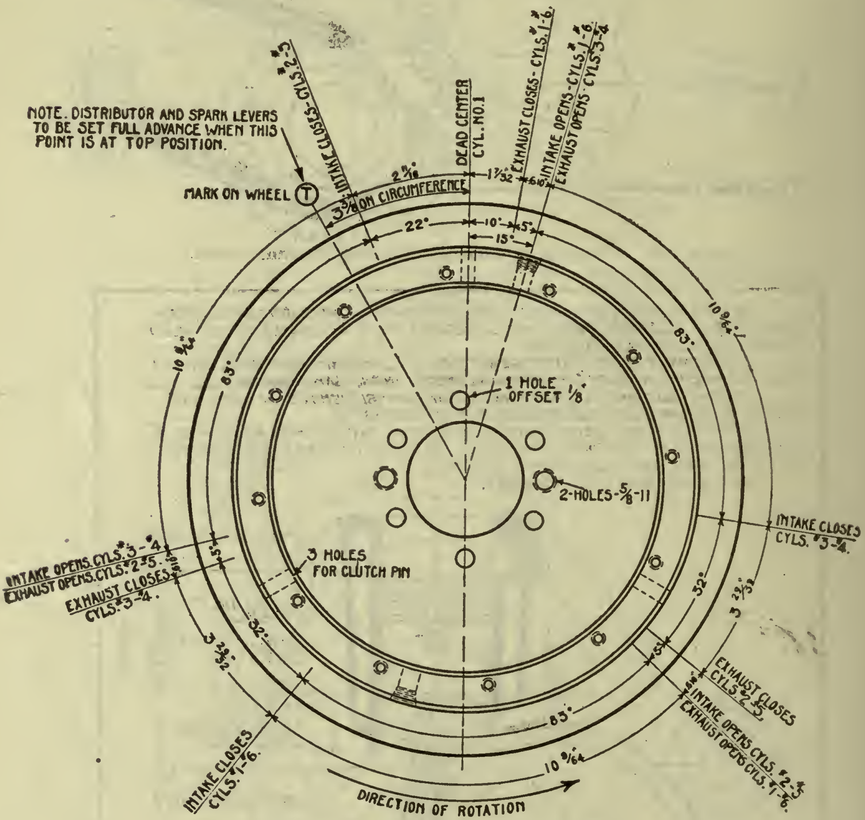


Fig. 179. Nash Flywheel Timing Chart.

cannot be exercised in overhauling an engine to see that it is properly maintained.

JOB 64. SILENT CHAIN CARE.

The chain-driven cam shaft and timing gears are used to a very considerable extent. The silent chain is also used to drive the generator, pump, magneto, etc. In some cases it is used to transmit the power from the starting motor to the engine shaft. In service the chain will be stretched and should be adjusted at each 5000 miles to compensate for the wear. In most cases the play or shake in the chain should be about ½" at the point shown in Fig. 180. This is standard practice. A chain either too tight or too loose is prone to be noisy. The one too tight is also subject to breakage and causes undue wear on the bearings. The one too loose is likely to jump from the gears and thus do great damage.

There are several methods of tightening chains. In many cases where the generator is chain-driven, the chain is tightened or loosened by manipulating the eccentric block through which the end of the generator shaft enters the chain case. In other cases an idler gear is utilized. Where great wear and stretch are apparent it may be necessary to remove one or two links. In cases where two links may be removed at one time the chain may be connected without any trouble. Where only one link may be removed the two ends of the chain will not fit together and permit alignment. To correct this fault

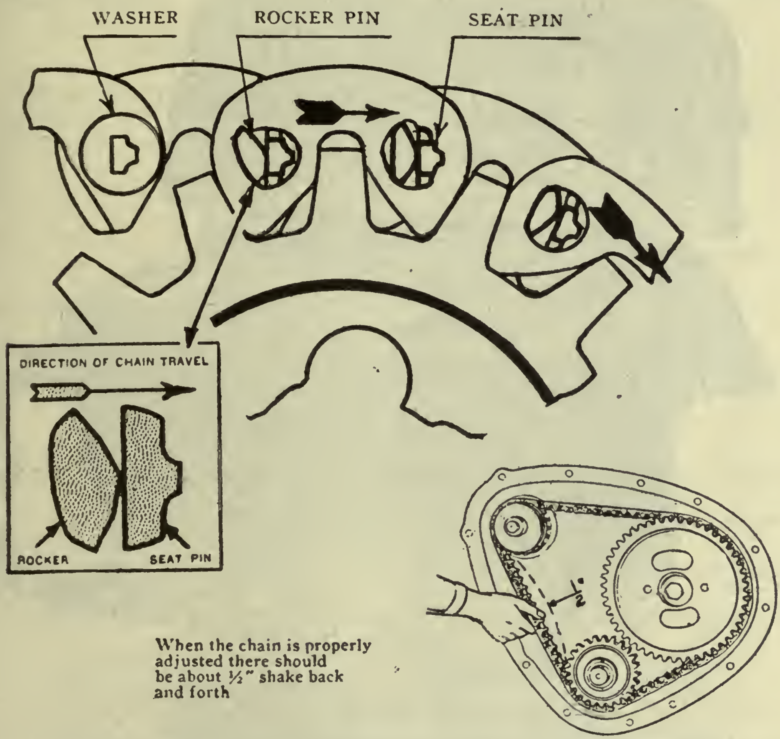


Fig. 180. Silent Chain Adjustment and Assembly (National Sextet).

two links are removed and a hunting link is substituted. This link will align the ends of the chain properly.

OPENING CHAIN. Two methods are in use in this work. Some chains are provided with a special link which is fastened in place with cotter keys, or wire, or other special fastener. In some cases no special link is provided and the ends of the seat pin, Fig. 180, are riveted over the washer thus inclosing and retaining the rocker pin which is made shorter than the seat pin. When the chain is riveted together at each pin it will be necessary to file off the riveted end of the seat pin to remove it. When replacing seat pins, new pins should be used to permit of making a workmanlike and safe job. It is also well for the student to learn the direction of rotation of the silent chain. Arrow heads are sometimes stamped on the chain links to indicate this. As shown in Fig. 180, the seat pin should travel ahead.

LUBRICATION. In practically every case the chain is housed in the timing gear case and lubricated by the engine oiling system. This is splash

in some cases, in others the chain dips into a well of oil, and in others a stream of oil is fed onto the chain as it runs.

JOB 65. REMOVING A CYLINDER HEAD.

A large percentage of cars use engines fitted with removable heads. This in itself is a most splendid feature when it comes to carbon removal, valve

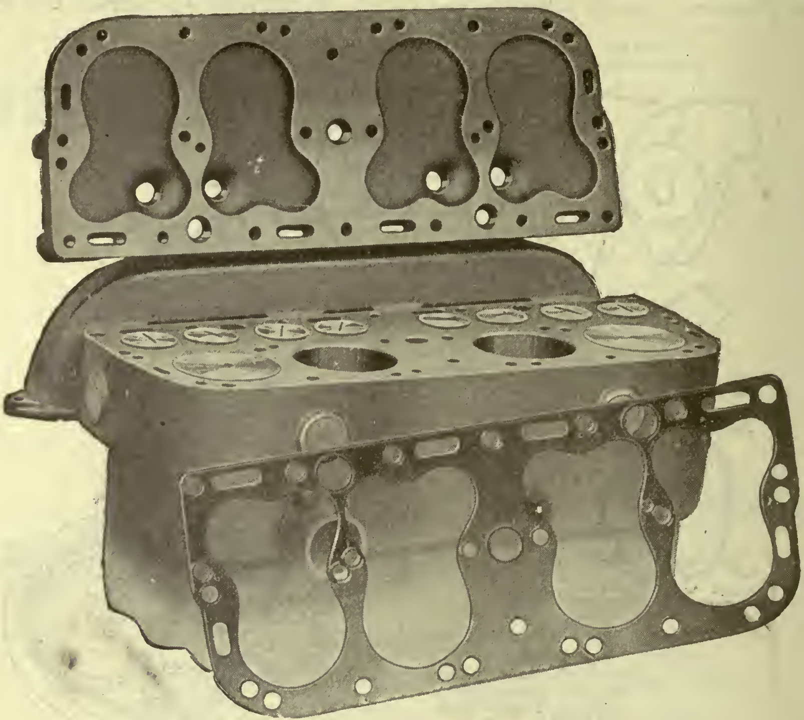


Fig. 181. Removing a Cylinder head (Allen).

care, etc. On the other hand, a cylinder head carelessly handled may be the source of much trouble. The act of removing the head is one requiring good judgment on the part of the mechanic. The following outline of steps for this work will help the student:

1. Drain the radiator.

2. Remove all hose connections which will prevent the head being lifted free.

3. Loosen all other parts such as vacuum tank and horn which may be attached in any way to the head.

4. Remove all the nuts or studs holding the head in position.

5. Test head with the hands to see if it is loose.

6. Failing to be able to loosen the head with the hands the engine may be cranked over. The compression will break the head loose. When using this method to loosen the head it is well to have a nut or stud in place at each end to prevent the head being forced all the way off.

7. When the head is loose, the next step is to get it raised far enough to permit the workman lifting it by placing his fingers between the cylinder head

and the block. This may be accomplished by the judicious use of a screw driver. The gasket will be harmed by the screw driver if the point is jabbed into it.

8. With the head blocked up to permit the workman to grasp it, the usual practice is to stand astride of the engine while raising the head up and off the studs.

9. Next raise the gasket from the block, using extreme care that it is not twisted, kinked, or otherwise harmed. Put it in a place where it will be safe from any abuse.

JOB 66. REPLACING A CYLINDER HEAD.

The work of replacing a cylinder head in such a manner that no parts will be damaged, and yet that all joints may be perfectly sealed, is a difficult one for the inexperienced. The following suggestions will be of help:

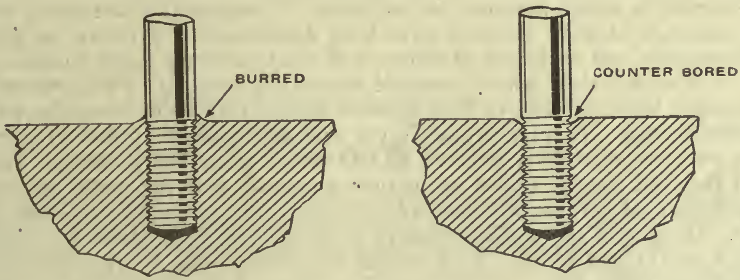


Fig. 182. Method of counterboring to relieve tight point on cylinder head assembly.

1. Clean all carbon deposits, rust, grease, or dirt from the machined surfaces of the head and block.

2. Test with a straight edge such as a steel rule or square to see that the two surfaces are true.

3. Remove any and all burrs around the edges and around the studs such

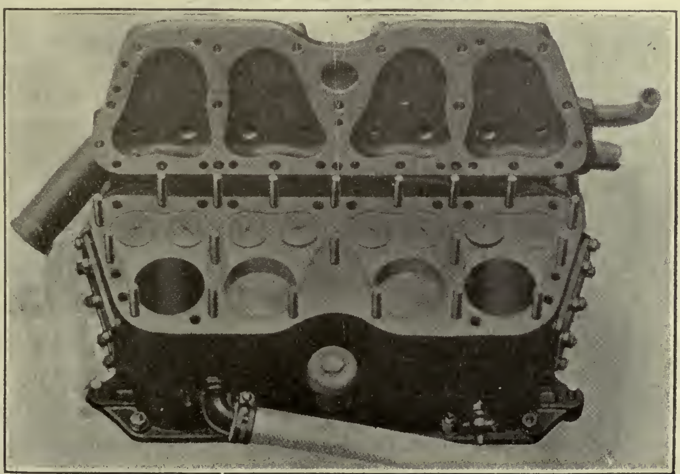


Fig. 183. Cadillac, right hand cylinder head removed.

as those shown in Fig. 182. Where the burr is around the stud, the stud should be removed and the hole countersunk. Burrs raised around the edges should be removed with a flat file. If the gasket has been shellaced on, the old shellac will have to be scraped off. Make certain that there is nothing at any point which will prevent the head from coming down evenly.

4. If the old gasket is badly worn and in poor condition the best and safest plan is to replace it. A gasket well cared for should last for five or six head removals.

5. Coat the gasket both sides with cup grease; also place a light coat of cup grease on the machined surfaces of the head and block.

6. Place the head in position making certain that there are no tools, studs, nuts or other objects in the cylinders.

7. Place in all studs, or if they are already in the block, place on all nuts, running them down until all are ready to seat on the head. With a socket wrench which fits the heads or nuts properly, draw each stud in turn until all are exerting a slight pressure on the head. Continue this operation until by the most careful work all studs have been drawn tight. To draw on one stud to the neglect and exclusion of others will most certainly cause trouble.

8. A stud is tight when a decided pressure is brought to bear on the head. By using a large wrench, or long handled one, it may be drawn tighter than is actually needed. This may result in the cylinder block being distorted in some cases and this distortion may be so bad as to cause leaky valves. In other cases the stud may be pulled up in such a manner that the metal immediately around the stud is raised and instead of the leak being stopped it is made worse.

9. In cases where undue pressure or force is used the studs are frequently broken off in the block. This means the head must be removed and the broken stud taken out.

10. After the engine has been run long enough to warm it up thoroughly the next step is to go over all studs once more to give each one a final turn. This is usually possible due to the fact that the heat has expanded the stud a bit, and also to the fact that the heat will run out some of the cup grease.

JOB 67. SHELLACING A CYLINDER HEAD TO PREVENT COMPRESSION LEAKS.

It frequently happens that due to an old gasket, or head, which is in bad condition, it is difficult to make the cylinder head gasket joint leak-proof. In making a test to learn if the gasket is permitting leaks, proceed as follows:

1. Remove head and gasket.
2. Clean free of all grease.
3. Coat the gasket each side with white lead.
4. Replace the gasket and head.
5. Run the engine, under load if possible.
6. Remove the head again. Any points where the white lead shows black streaks are points at which the compressed gasses have been leaking from the cylinders.
7. Clean the gasket of all the lead, grease and oil.
8. Coat the gasket and machined surfaces of the head and block with a thin coat of rim and gasket shellac.
9. Allow the shellac to dry until it is tacky to the touch. Apply the head in the usual manner.
10. In cases where cylinder head gaskets develop serious leaks between the cylinders, it is sometimes advisable to shellac in a strip of paper on the part of the gasket indicated by the arrow in Fig. 184. This will prevent the compression starting a leak which will later develop into serious trouble.

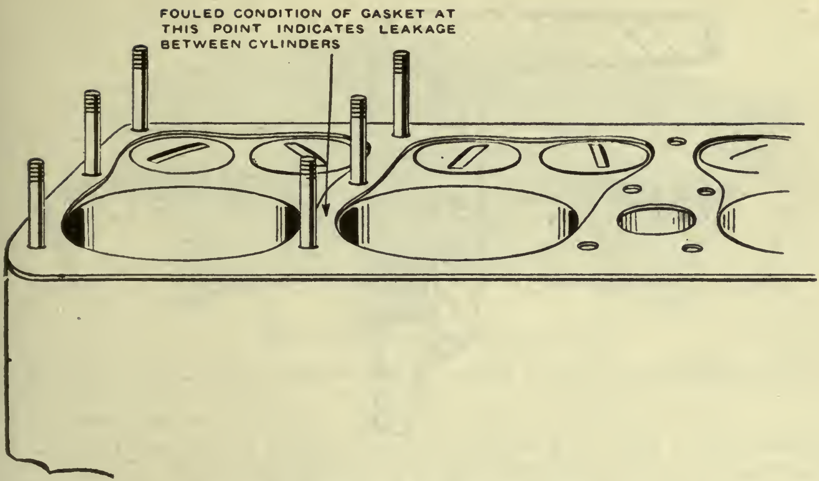


Fig. 184. Hudson block with head removed.

JOB 68. FITTING NEW PISTON RINGS.

To properly seal the walls between the piston and cylinder the piston ring must be most carefully fitted. Three forms of clearances must be figured by the mechanic. The side and back clearances are illustrated in Fig. 186. The end clearance is illustrated in Fig. 187. These clearances are figured always in thousandths of an inch. A feeler gauge is absolutely necessary to a good piece of work. The workman who attempts jobs of this nature without the proper measuring devices, depending on his eyesight alone, will never earn the title of mechanic. The person with a trained eye may tell the difference between .002″ and .004″, but the average workman can not say with any degree of accuracy whether a certain space is .010″ or .030″. In fitting new rings proceed as follows:

1. Drain the radiator, remove the cylinder head, and do such other preliminary work as may be necessary to remove the piston. Make certain that the piston rod and cap are properly marked so as to insure their proper return to the original cylinder. Do not lose any shims from the bearing.

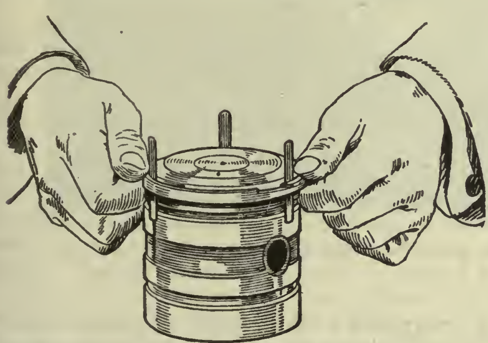


Fig. 185. Using skids to remove piston rings.

2. Remove the rings. If difficult to remove, use three old hack saw blades or strips of sheet metal to slip under the rings and hold them expanded while slipped over the ring grooves. Fig. 185.

3. If the old rings are to be used again they should be maintained in order that the top one may be returned to the top groove, and so on.

4. To learn if the old rings are fit to be used again, first roll them in the grooves of the piston to note side clearance. This should be just enough to

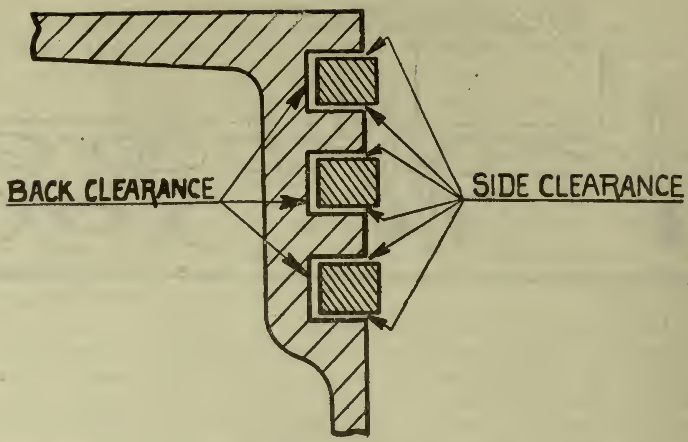


Fig. 186. Piston Ring Clearance.

allow them to slide without gripping the sides of the groove. In other words, there should be no appreciable play up and down in the groove. Fig. 190.

5. Test the old ring in the cylinder to learn if there is an excessive amount of end clearance. If this is .003″ or more for each inch of diameter of the cylinder, the ring should be replaced with a new one. For instance, if the thickness gauge shows this end clearance to be more than .009″ for a 3″ piston the clearance is too great and the ring needs to be replaced.

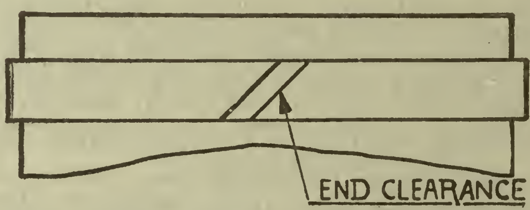


Fig. 187. Piston Ring Clearance.

6. In fitting new rings the first step is to secure the proper size of ring from the supply house or dealer. Usually these are a bit large and to fit them the ends must be filed to permit of the proper clearance.

7. Place the new ring in the cylinder. File off the end until it will just lay even with no clearance.

8. Note whether the ring lies in close contact with the cylinder walls at all points, or whether, with a light beneath it, it shows away from the walls at certain points. If it does stand away a considerable amount at any one point, it may be necessary to pien it at that point to make it conform more nearly to the cylinder. This is a job requiring patience or the ring will be broken. Rings are cast grey iron. Fig. 188.

9. With the ring conforming pretty well to the cylinder, it may be placed on an old piston or on a dummy piston and lapped to a still better fit. To do this, place a bit of fine valve grinding compound on the ring's outer surface. Moving the dummy piston and ring up and down in the cylinder while giving it a circular motion will quickly fit the ring to the cylinder wall. Do not use the coarse grinding compound in this lapping operation. Clean the ring and

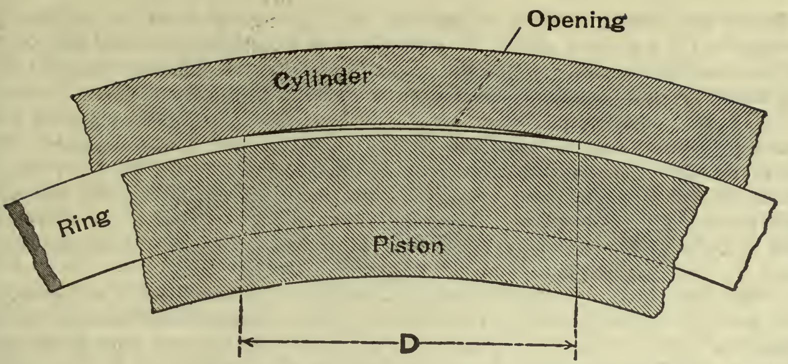


Fig. 188. Piston Ring in need of piening to make it fit up to the cylinder wall.

the cylinder most carefully after the operation is completed.

10. Put the ring in position in the cylinder and make a test with the thickness gauge for end clearance. The top ring should have a clearance of .0015″ to .002″ per inch diameter of the cylinder. The lower rings, not being subjected to quite as much heat as the top one, may be a bit closer. File until proper clearance is obtained, remembering that in the case of the bevel cut lap when the clearance shows on the gauge as .004″, it is in fact .006″, or one and

Fig. 189. Using a thickness gauge in fitting a piston ring. Measuring end clearance.

one-half times as great as the thickness gauge shows. This fact is due to the angularity of the lap. A step cut ring will show the actual clearance when measured.

11. The next point is to test the side clearance and fit the ring into the piston groove. In this work the ring is rolled around the groove as indicated in Fig. 190. Starting at different positions make at least three tests to see if the ring appears to be the same width at each point. If too wide, the width is

reduced by placing a sheet of medium or fine emery cloth on a plate glass surface or on a surface plate. A perfectly true bench top or board may be used in case nothing better is at hand. Grasping the ring under the finger tips the mechanic gives it a rotating motion on the emery cloth, testing each little while to see how it is being reduced. As quickly as one point shows signs of fitting, that point must be protected from further cutting as the work proceeds. When all points are just entering the groove, extreme care must be used so as to finish up the work in such a manner that the ring will just slide around the groove in the piston when it is put in position on the piston. It should have just a little tacky or sticky resistance to sliding. The piston expands more than the ring when heated and will clear it nicely.

12. The final test for the ring is to learn if the ring is a bit thinner than the groove is deep. This is the back clearance and should be .002″ per inch diameter of the piston. Too great a clearance allows the carbon to collect back of the ring and this in turn may cause rings to stick.

13. Carefully fitted rings will do more to repay for the expense of making the job right than perhaps any one other thing. They mean more power, more mileage, less oil consumption, less fuel consumption, less carbon accumulation, less bearing trouble and fewer repair bills.

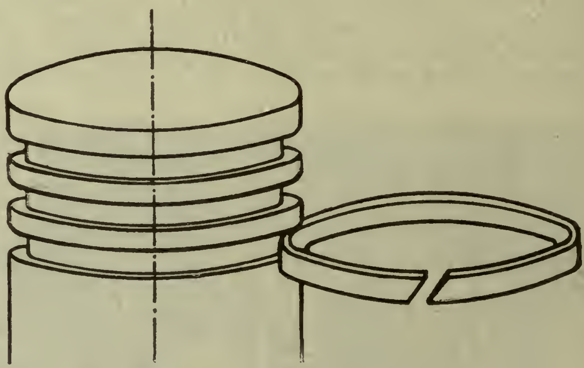


Fig. 190. Fitting Piston Ring to Groove.

JOB 69. FITTING NEW PISTONS.

There are a number of causes which contribute to such wear, normal, or abnormal, which make necessary the fitting of new pistons. If no abnormal conditions are present the engine will give many miles of service without the pistons or cylinders wearing to such a degree that the old pistons must be discarded and new ones installed. However, even in normal service there is some wear on the piston and the cylinder tends always to wear out of round and egg shaped. Under abnormal conditions as when the engine overheats or is run without oil, or when the cylinders and pistons score for any reason, it is almost certain to produce enough damage that the pistons at least will have to be replaced.

In cases where the cylinders are scored badly as would be the case in piston pin scores, the cylinder block would have to be repaired or replaced. In the minor cases of scoring, and to correct the cylinder worn oval due to long service, the following method may be used to fit new pistons. If the cylinder is worn from .010″ to .015″ out of round the job is one requiring reboring and the following method would not give a mechanically correct job:

1. Tear down the engine and get the cylinder block in such condition

either in the frame of the car, or on the bench, or stand, that the work may proceed without hindrance.

2. Measure up the cylinders to learn the size of the new pistons to be ordered. In some cases it is advisable to put the cylinders in good condition before ordering the new pistons.

3. To put the cylinder in good condition use an old piston for a lapping tool. Mount a handle on the wrist pin to use in working the piston up and down and round and round as the work is in progress. This handle may be made from wood, or from pipe fittings, or several old connecting rods may be bolted together at the yoke end and the piston fitted onto one of the piston pin ends with a round stick in the other piston pin end.

4. For a lapping or grinding compound it is best to use a valve grinding compound, selecting a grade which the work would seem to require. If a coarse compound is used to start the work, the finer grades must be used to finish it and to remove all the scratches. Avoid emery compounds for this operation.

5. The ideal motion for the work of lapping or grinding is a revolving one, supplemented by a vertical or in and out motion. To simply work the piston up and down in the cylinder without turning it will not grind it true. The revolving motion is essential in grinding the cylinder round.

6. The work is difficult and requires patience and skill. After grinding for a considerable time the piston will become so small that the work is hindered. A larger piston must be substituted, or the one in use must be split with a hacksaw in such a manner that the two sides may be wedged apart a bit to compensate for the wear.

7. When the cylinder has been brought to a fair degree of accuracy which can be determined with a pair of inside calipers or micrometers, the new piston may be fitted. To do this use fine valve grinding compound and lap or grind in as suggested for the use of the old piston.

8. The clearance of the new piston should be figured according to the manufacturer's specifications, or failing knowledge of that, the allowance may be figured as follows:

For cast iron pistons allow .001″ to .0015″ clearance for each inch cylinder diameter at the top of the piston. The skirt, which is not subject to as great degree of heat, may be made a closer fit, .00075″ per inch of diameter being recommended.

For aluminum pistons allow .003″ to .004″ for each inch of cylinder diameter at the top of the piston. Allow somewhat less clearance at the bottom.

9. Pistons should be fitted from the bottom of the cylinders and in their natural position.

10. In running in new pistons and new rings care must be exercised to have plenty of oil and not to operate the engine at excessive speeds.

JOB 70. SCRAPING OUT CARBON.

This is a piece of work readily learned by the student. The actual work of removing the carbon by scraping where the head of the engine may be removed is slight.

1. Remove the head. Job 65.

2. Scrape all the carbon from the tops of the pistons, the valves, and the cylinder block. Use a putty knife and screw driver to scrape with.

3. Scrape all the carbon from the cylinder head. Use any round nose tool to work into the corners.

4. If plugs need it clean them of carbon. Never take a spark plug apart or attempt to help its condition as long as the porcelain is burned a clean brown or tan.

5. Wipe all parts free of carbon and carbon dust.

6. Replace head. Jobs 66 and 67.

7. Where the head is cast integral and it is desired to remove the carbon by scraping, the first step is to remove all of the port plugs.

8. Bring the piston in cylinder No. 1 to top dead center on compression stroke. This leaves both valves closed.

9. While in that position proceed to scrape the carbon loose. Use compressed air to blow it from the cylinder.

10. This work requires patience and some thought. The mechanic must be able to visualize the inside of the combustion chamber and the work of his scraper. He can not see how the work is coming. He will in time learn the feel of the scraper and know when the work is completed.

11. Scrapers for this work come in sets of three and are made from cold rolled steel. In special cases where none of the scrapers seem to fit they may be bent to such shape as may be best, or other special scrapers may be made up.

12. When each of the cylinders in turn has been finished the port plugs are cleaned. These plugs will frequently give as much trouble with compression leaks as would a removable cylinder head. This is due in practically every case to abuse in handling them. Proper tools to turn them are not at hand and the mechanic uses a punch and hammer to turn them. This results in distortion of the machined seat with the result that no gasket will make them tight.

13. To prevent trouble at this point it is good practice to use flake or powdered graphite mixed to a paste with machine oil to coat the threads with when replacing them.

14. Turn the port plugs in snug. Heat the engine by running and give the plugs another turn.

CHAPTER 7

OILING SYSTEMS

To facilitate a study of engine lubrication, the main types of systems only will be mentioned. These are:

1. Splash.
2. Splash and circulating.
3. Force feed.

Of the latter two there are a number of variations. The student

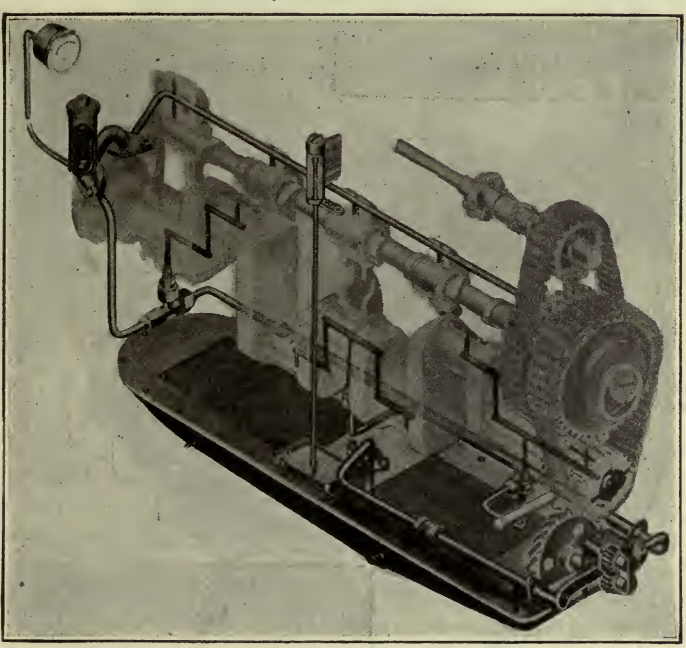


Fig. 191. Cadillac Oiling System.

must not lose sight of the purpose of the oiling system while learning the details of design.

Full Splash.—The full splash is not used in automobile engines today. It is still used to a certain extent in marine and stationary engines, where the engine remains largely in a level position and is not tilted on an angle for considerable length of time as in hill climbing. Here an outside supply is arranged to drop a certain amount of oil into the single oil reservoir into which the rods are dipped. Tilting the engine runs all the oil to one end of the oil pan and while over oiling some parts it is under lubricating others.

The Splash and Circulating.—This is perhaps the most popular

for fours and sixes as it is not so likely to cause trouble. Here oil is carried or pumped from a reservoir to a second level in the oil pan and allowed to fill up oil wells or grooves into which the rod dippers may dip at all times. To accomplish this result satisfactorily each rod has its own well, and coming onto a hill does not materially disturb the lubrication as the circulating system keeps the oil supplied to these wells from which it is splashed up into the cylinder walls, piston walls, valve ports, and onto piston rods, piston pins, valve tappets, cams, cam shaft bearings, and timing gears. Besides,

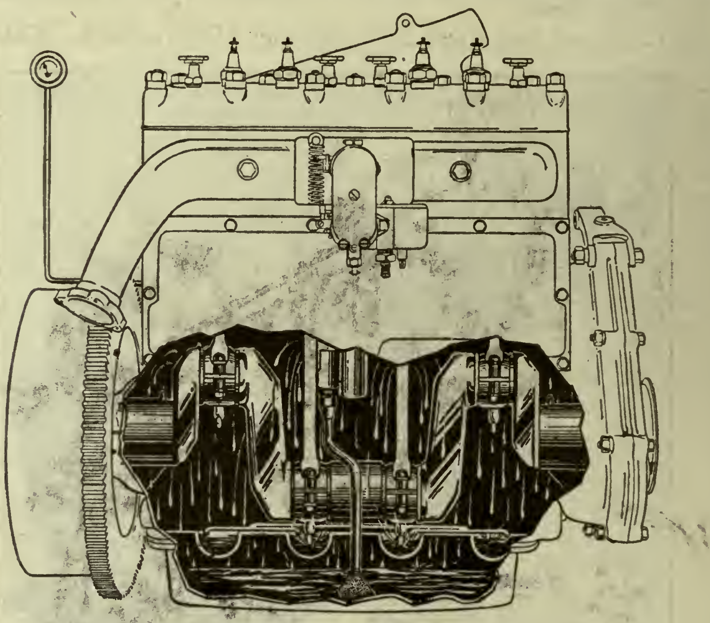


Fig. 192. Overland Splash and Circulating Oiling System.

a vapor is even supplied to valve stems, and springs inside the inspection plates, or under the valve cage covers.

Usually the oil pan is made with two levels, the lower level acts as an oil reservoir, while the upper is the one which contains the oil grooves. As long as there is oil in the lower level sufficient to fill the pump well, or sump, the pump keeps the oil flowing to the upper level from which it is splashed and used to lubricate moving parts as indicated in Fig. 192. All surplus oil finds its way back to the lower oil level ready to be recirculated.

Forced Feed.—There are several varieties of force feed. This is particularly adaptable to the V type motor, as all attempts to use the splash system here have resulted in failure, due to more oil being splashed into the left-hand block (from driver's position) over-lubricating it, and under-lubricating the right-hand block.

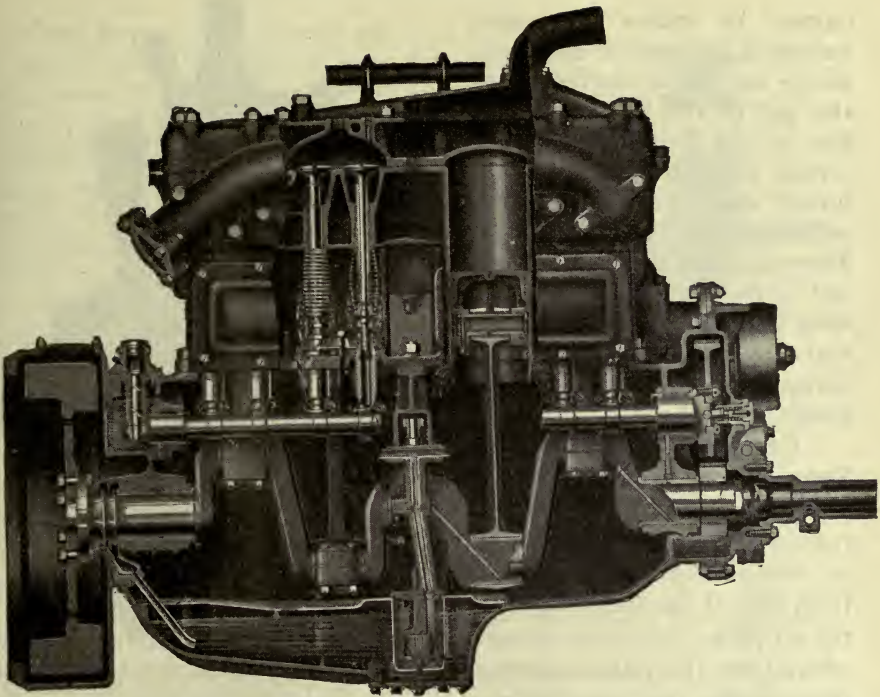


Fig. 193. Buda Engine. An example of the Full Forced Feed oiling system. Note the drilled crank shaft and the direction of travel of the oil through it.

In the force feed system the oil is circulated from the oil sump in the oil pan through a screen into the circulating tubes, into the main bearing caps, from where it finds its way through oil grooves and holes, into the crank shaft which has either holes or tubes provided for carrying the supply to the crank pins within the rod bearings. From this point the oil is sprayed onto the cylinder walls and piston pins, cams, tappets, etc.; or in what is termed full force feed the oil is forced still farther and carried up through the connecting rod, or along it, through a tube to the piston pin, from which it is forced to the piston bushings and cylinder walls and rings. The cam shaft bearings are also fed by oil under pressure, while the cams, valve lifters, gears and chains are very largely dependent on splash, even in the full force feed.

While the splash of oil often plays a very distinct part in the force feed the student must remember that there are no dippers on the rods, nor is there any provision for the rods to dip into the oil and splash to the other parts. Rather the unused portions or surplus of oil forced to the engine bearings are sprayed or splashed or thrown off as the shaft turns. Fig. 195.

Oil Pumps.—In automobile engine oiling systems, the oil is cir-

culated by means of pumps, except in the case of the Ford, where the oil is carried up to the top of the flywheel housing by the flywheel, where a certain amount is caught in the funnel shaped opening of the oil circulating tube and then flows by gravity to the front end of the engine. Other systems utilize the gear pump, the rotary vane or centrifugal pump, and the plunger type pump.

Centrifugal or Rotating Vane Pump.—This type of pump as used in the Dodge consists of a vane or impeller so driven that oil is drawn from the oil sump coming into the oil pump case, then thrown off and out at another opening, thus finding its way to the bearings, oil wells and grooves.

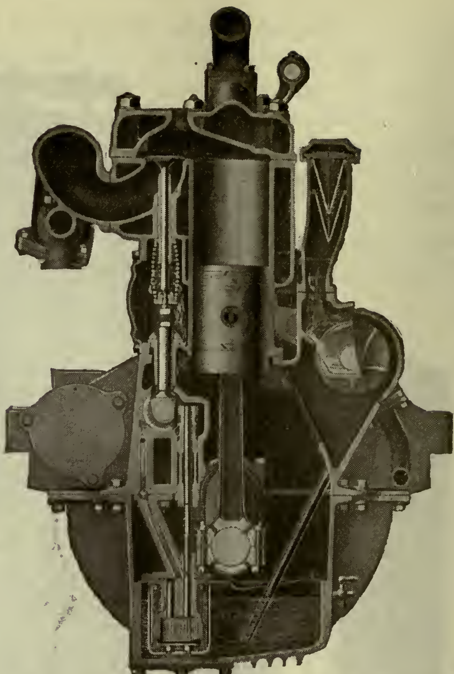


Fig. 194. Buda Engine. Timing Gear end view of the Full Force Feed oiling system. Note the operation of the Geared oil pump and the saber type of oil gauge. Note parts lubricated by splash.

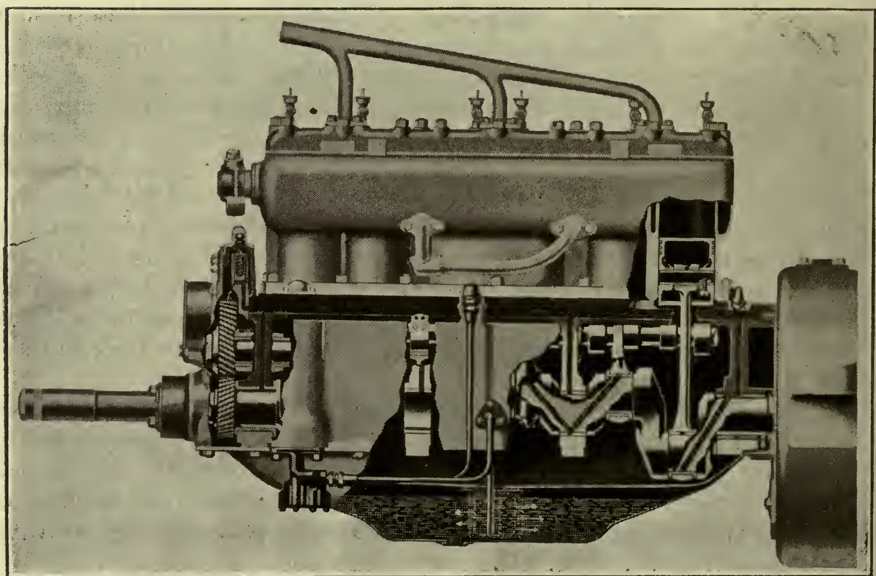


Fig. 195. Continental Red Seal 7R. Full Pressure Lubricating System.

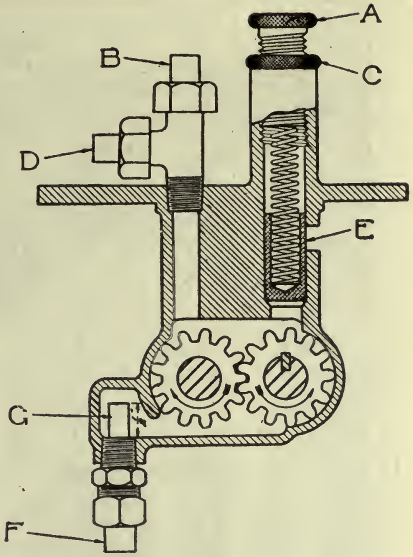


Fig. 196. Haynes Gear Type Oil Pump.

Gear Pump.—In this case oil is taken into the oil pump case and thrown off by two small gears having teeth of coarse pitch. These gears are driven from the engine and oil coming in goes around the gears and not between them. A small quantity is carried between each tooth and the pump case, much as the old chain pump carried successive cups of water to the top of the well and dumped it in a flowing stream from the spout of the pump. Oil coming from one side meets that coming around the gear from the other side and more and more is brought around; circulation is started and continues as long as oil remains or the engine continues to operate.

Plunger Type Pump.—In the plunger type pump commonly used on the force feed system, oil is drawn into the pump body after which a valve closes; as the plunger descends the oil must be forced out. An opening with another one-way valve is provided for this. After the oil has been forced out the plunger starts upward again, when the second valve closes to prevent oil being drawn from the lubrication line rather than the oil sump or well. However, the first valve has again opened and permits oil to enter. The operation continues regularly, the check valves controlling the direction of flow. The amount of flow is controlled by adjusting the length of stroke on the plunger which is usually operated by cam action.

Indicating Devices.—There are two general methods of indicating the working of the oiling systems, the sight feed and the pressure gauge.

Sight Feed.—In the case of the sight feed a small metallic case with a glass dial is placed on the dash or instrument board. As the oil is circulated by the pump it is carried to the sight feed into which it may be seen flowing. A small vane is mounted in the instrument at times in order that the action or flow of oil may be more readily detected. From the sight feed the oil returns to the engine where it is used to lubricate the moving parts.

Pressure Gauge.—In the case of the pressure indicator the operation is similar to that of the air or steam gauges. Pressure in oiling systems varies from two or three pounds to as much as fifty in some

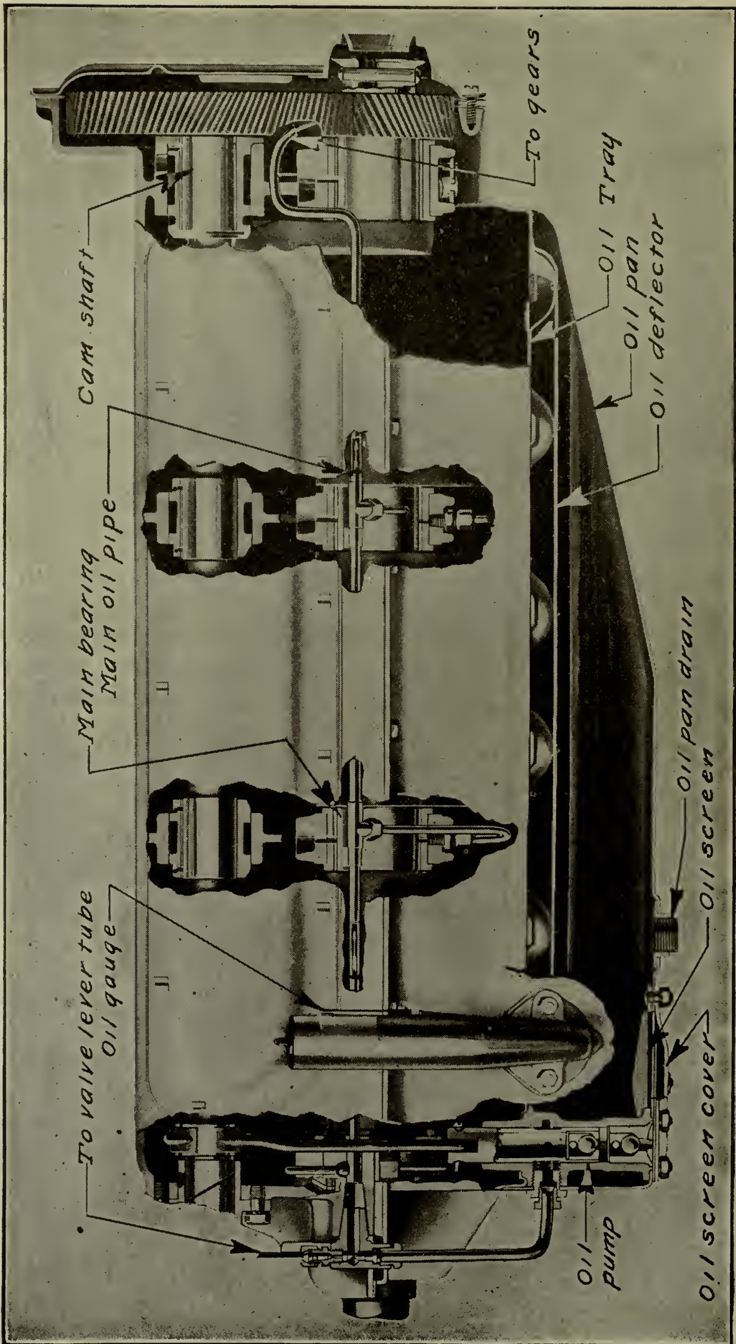


Fig. 197. Reo Oiling System. Arrow indicates the direction taken by oil as it leaves the pump and flows to the various parts.

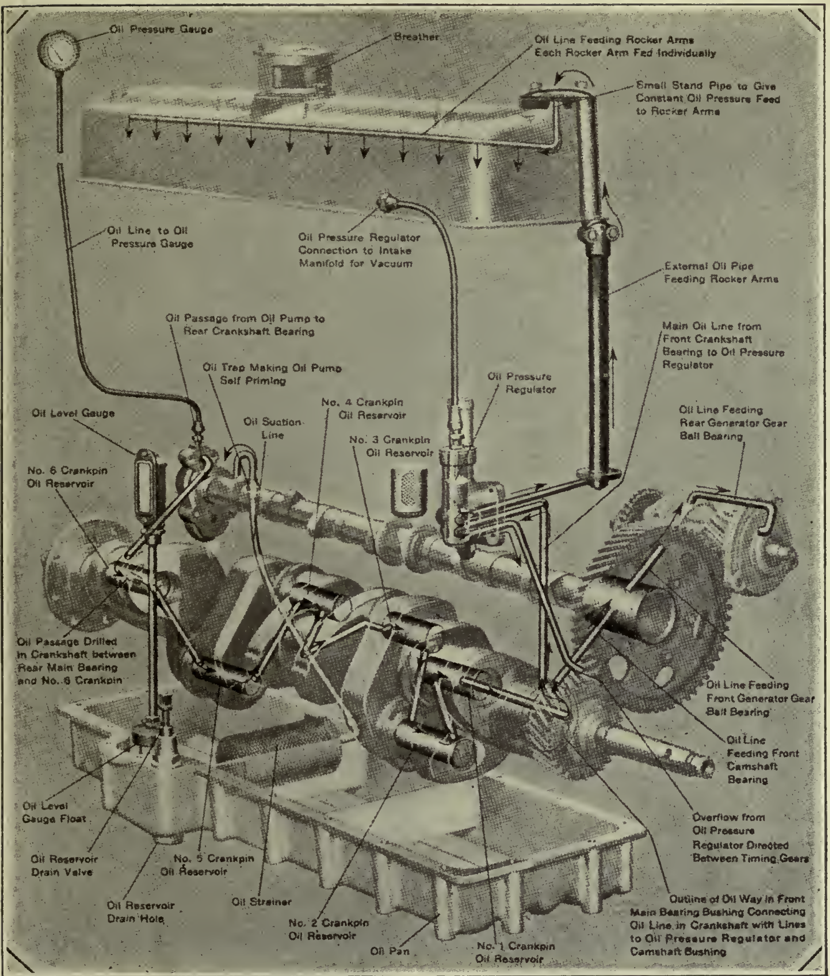


Fig. 198. Phantom view of Marmon Force Feed Oiling System.

high speed motors. In all cases the higher the speed the greater the oil pressure. The pressure gauge is mounted on the instrument board. A single copper tube runs from it and is connected to the oil lines. Oil flowing in the lines would also tend to flow to the gauge. Since, however, this line is filled with air, the oil cannot reach the instrument, and it is the air which actually registers the oil pressure. Thus, as the pump develops pressure it is registered on the gauge. These indicators are placed on the dash in order that the operator may know with some assurance, the condition of the oiling system. As long as oil continues to flow through the sight feed, the driver may

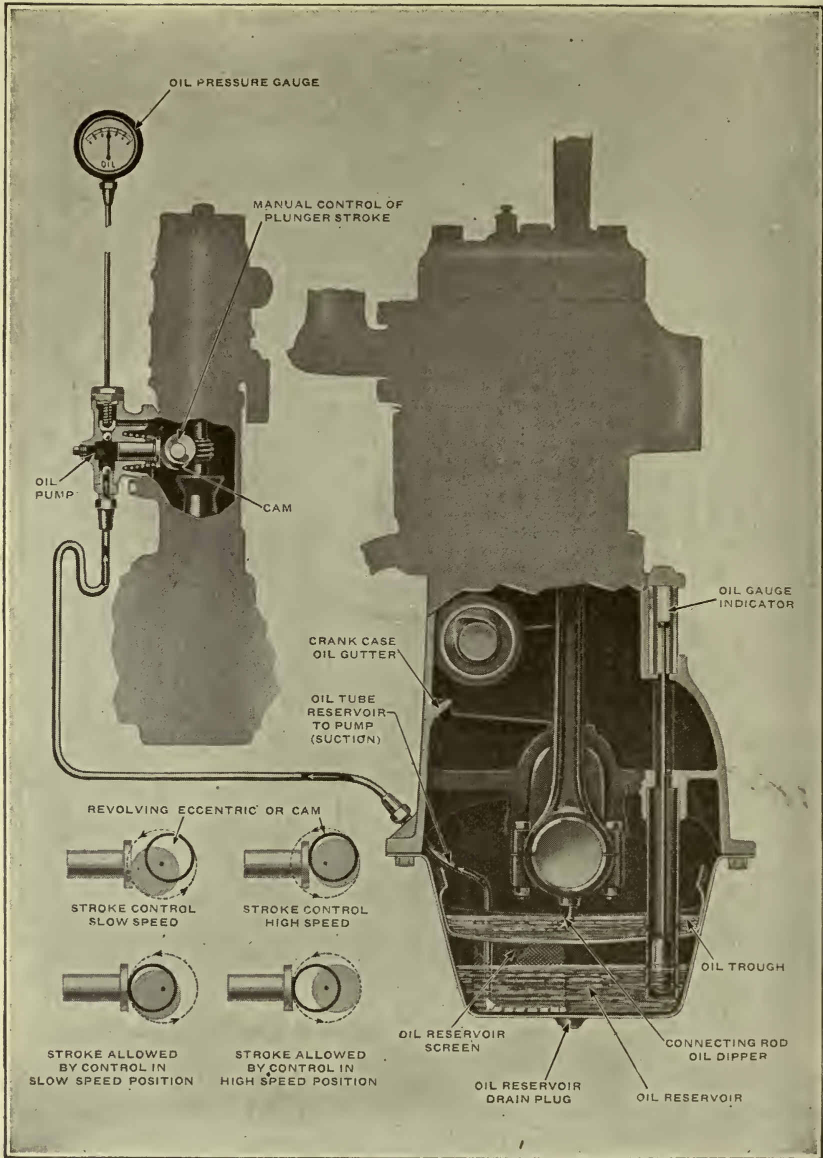


Fig. 199. Hudson Oil Pump Plunger Type.

know that there is oil in the motor and the system is working. If the oil fails to flow, the engine should be stopped immediately and the supply investigated. If the oil is low, refill. If this fails to correct the trouble the pump should be primed. Should this fail, the pump should be investigated for possible trouble and the oil line blown out

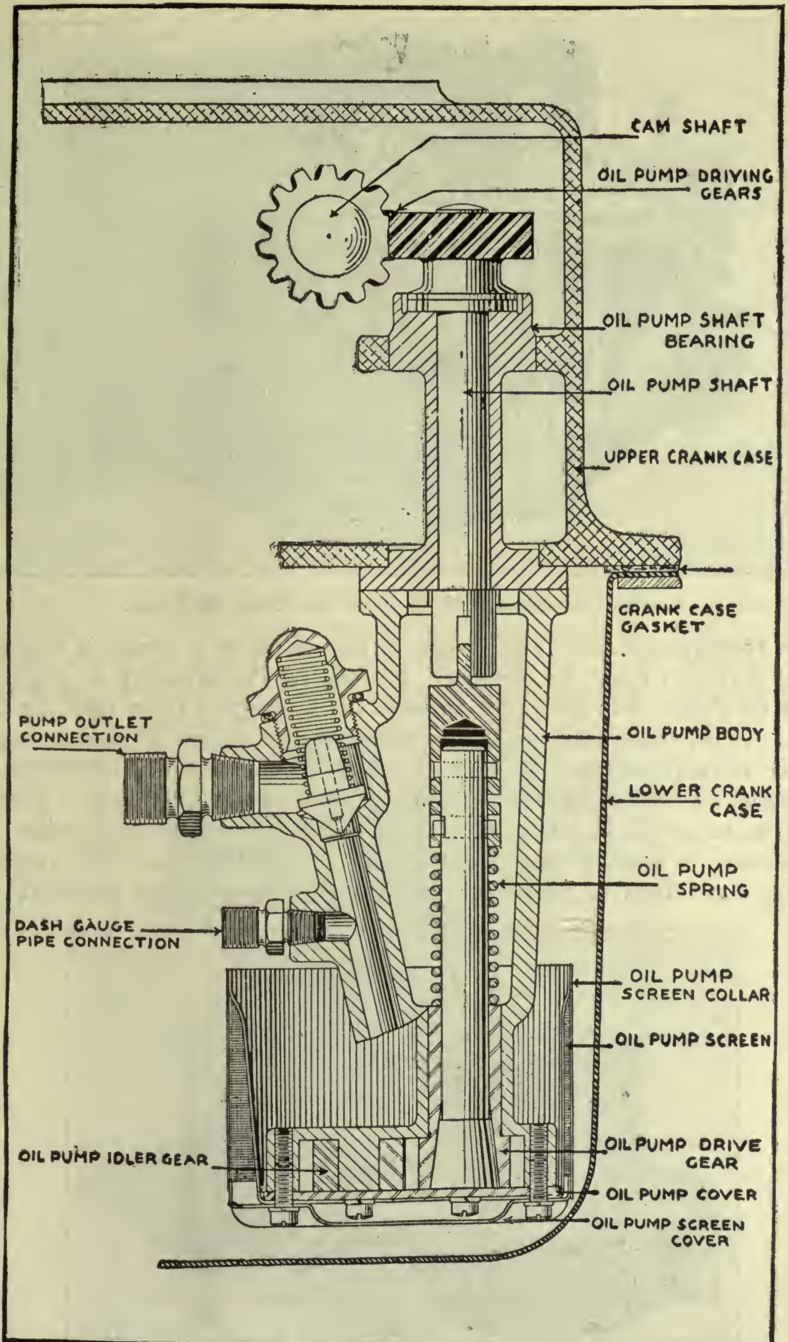


Fig. 200. Buick Oil Pump.

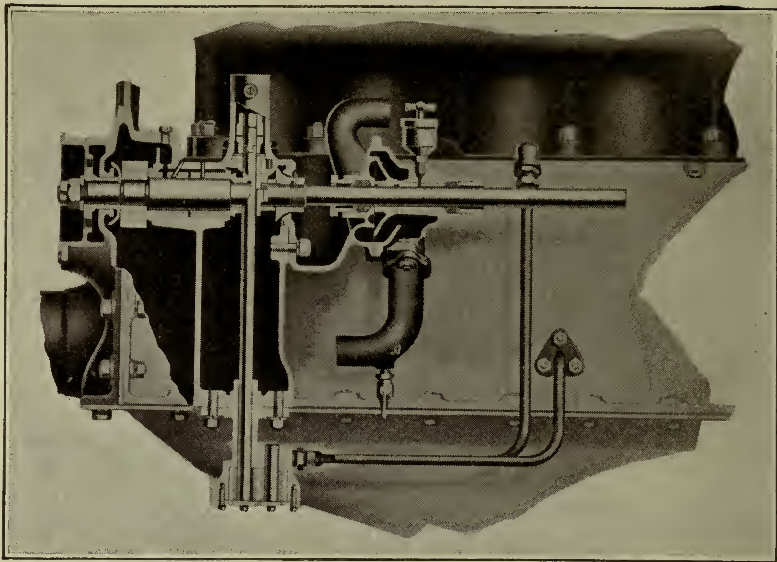


Fig. 201. Continental 7R showing Gear Type Oil Pump.

with compressed air. The screen in the oil sump at times is clogged with dirt and must be cleaned. Failure of the pressure to register may be due to a broken line, thinned oil, a clogged tube, etc. In the case of full force feed, if the pressure gauge shows a sudden jump above normal pressure, it may be due to dirt in the line or stoppage of some of the passages. Failure of any of the oil lines is pretty certain to result in badly scored or burned parts; usually some indications of approaching trouble may be detected on the gauges, either sight feed or pressure. Since cold always tends to make oil

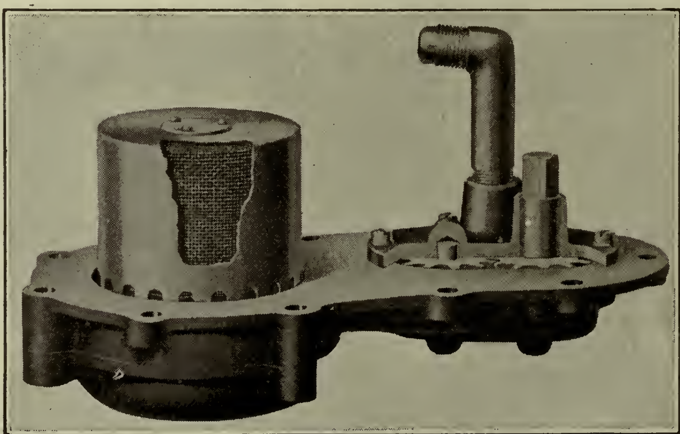


Fig. 202. Packard Truck Gear Type Oil Pump.

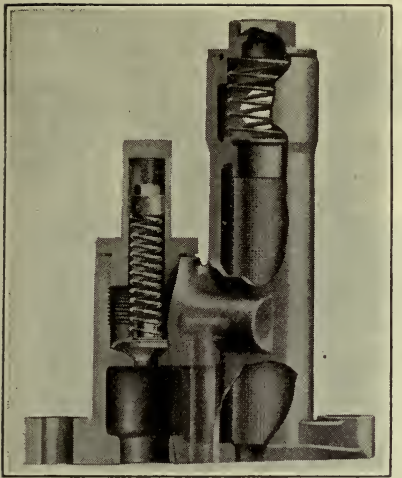


Fig. 203. Packard Truck Oil Strainer and Relief Valve.

heavier or thicker, the pressure on the gauge will show more in starting the engine than after the engine warms up.

Caring for Oiling Systems.—A properly functioning oiling system, properly cared for, will do more to lengthen the amount of service to be obtained from an engine than any other one thing. No system is flawless. No engine is flawless. Careless operation of the engine increases the likelihood of trouble. The exercise of proper care may do much to eliminate the development of trouble.

Oil Wears Out.—The grade of oil to be used is usually recommended by the manufacturer of the motor car. Generally speaking, the older the car the looser the parts have become, due to natural wear, and the heavier the oil permissible and desired. No matter what the grade or quality of oil, it will wear out. The purpose it serves is to provide a film between two metals to prevent them touch-

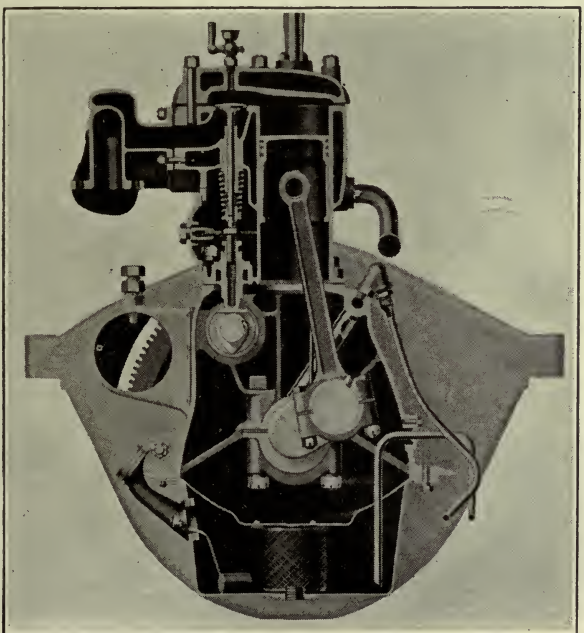


Fig. 204. Continental 7R showing Oil Strainer, Oil Lines, Floats, and Gauge.

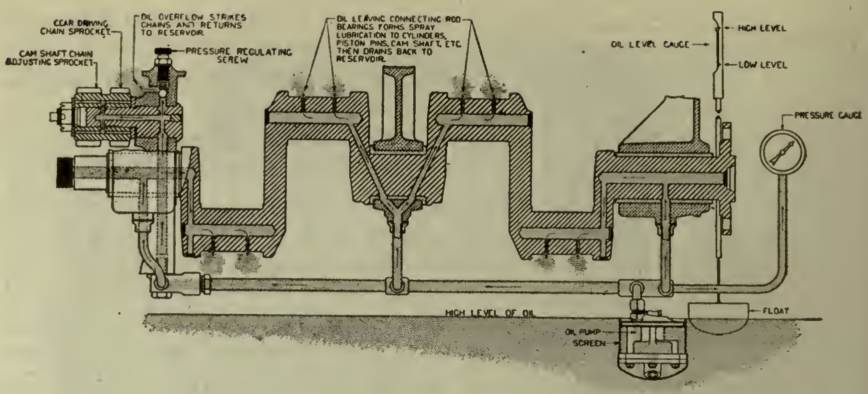


Fig. 205. King Oiling System.

ing each other. This is necessary to prevent wear as they perform their work, as for instance in the crank within its bearing, the shaft actually rides on the oil. The oil might be said to act similarly to the balls between the outer and inner race in a ball bearing. To provide for a heavier load, in the latter case, larger balls are used or a greater number of smaller ones. In the engine bearing, the greater the load the greater the bearing, consequently the larger the film of oil carrying the load. As the engine runs the oil is worn round and round in the bearings. It is hammered by the impact of the piston blows, and ground between the piston and cylinder wall. In this way small

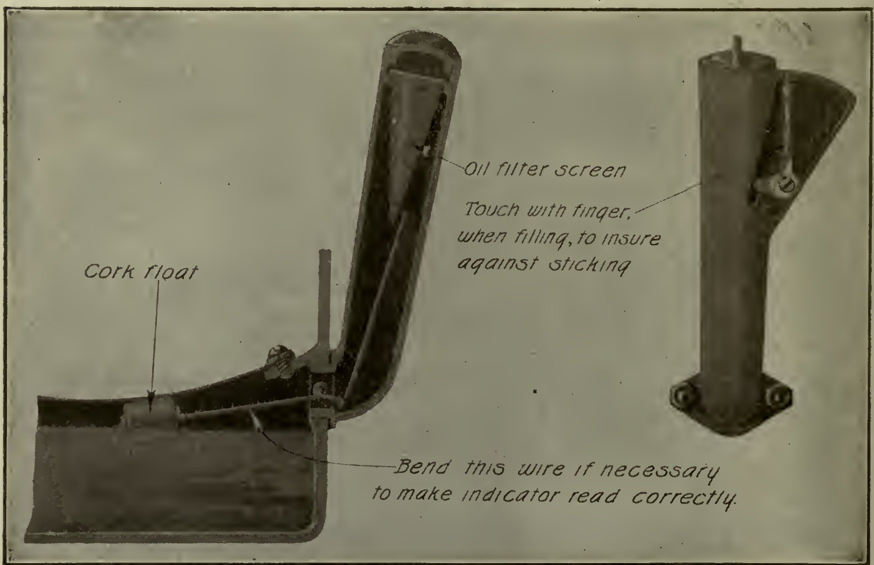


Fig. 206. Reo Oil Gauge and Filling Tube.

particles of metal are picked up. Carbon and gasoline also are carried down by it from the combustion chamber and it gradually accumulates such a quantity of foreign materials that it is no longer fit for lubrication.

Draining Oil.—When this condition is present it is necessary to draw the oil from the crank case, flush and refill with new oil. This should be done each thousand miles the car is run, during the summer.

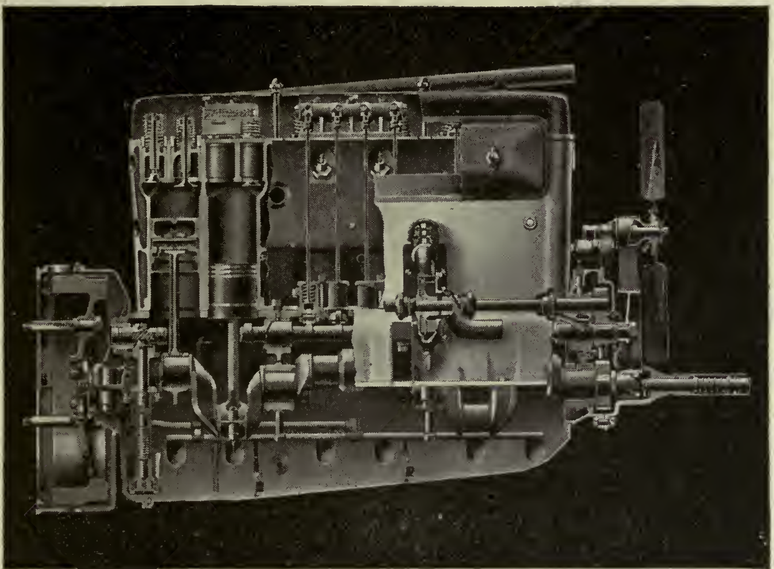


Fig. 207. Buick Motor.

In winter it may be necessary to drain the oil more often as the heavy grades of gasoline are hard to vaporize and more will be drawn into the cylinder than is burned. This works down into the oil and thins it out.

New cars, or cars just overhauled, should have the oil drawn from the engines after not more than 500 miles' service.

Troubles Due to Loss of Lubricating Qualities.—Destroying the lubricating qualities of the oil brings about many unsatisfactory conditions, for which there is no apparent cause. These conditions are usually difficult for the inexperienced driver to comprehend. Some of the troubles which are a direct result of the impaired qualities of the lubricating oil, are as follows:

1. Hard starting.
2. Premature piston wear.
3. Premature cylinder wear.
4. Premature piston ring wear.

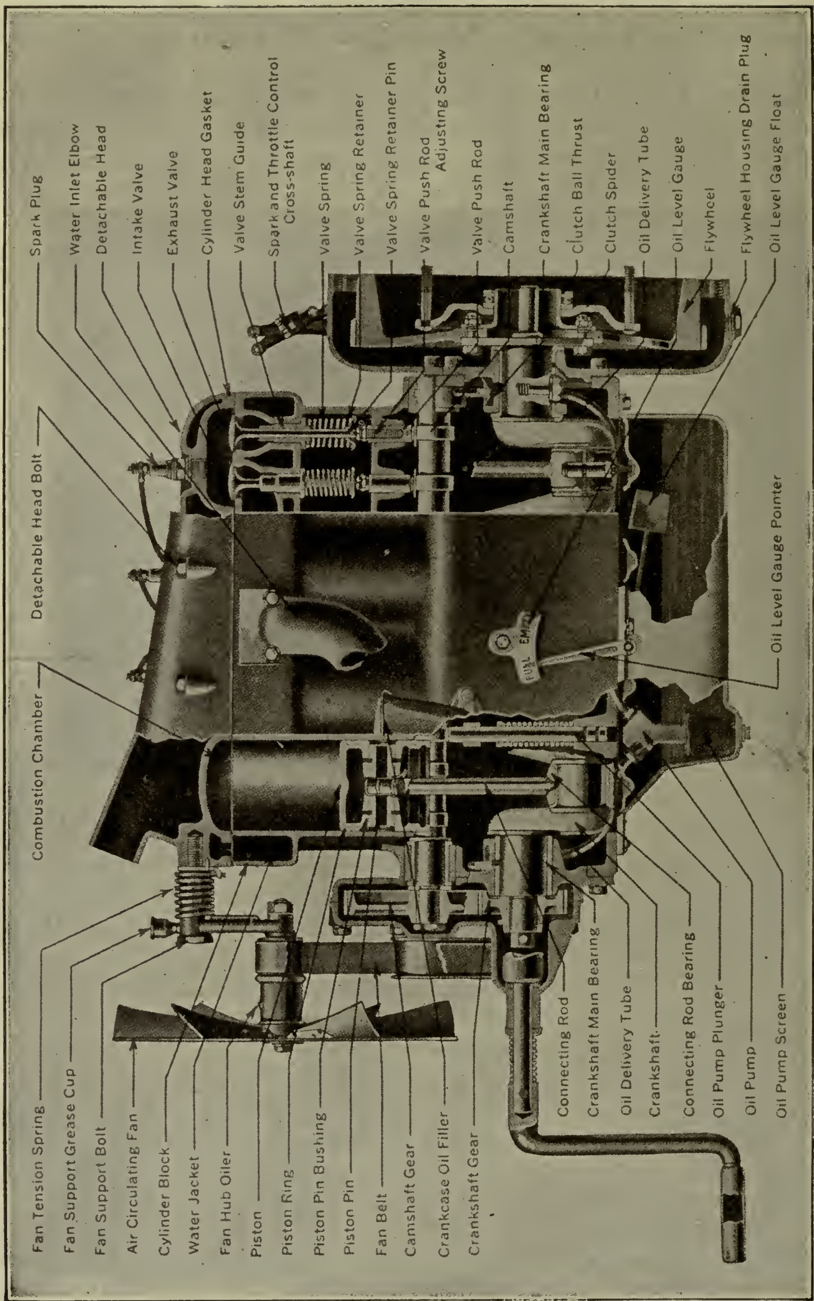


Fig. 208. Maxwell engine showing Oil Gauge and Oiling System.

5. Connecting rod bearings burning out.
6. Crank shaft bearings burning out.
7. Excessive gasoline consumption.
8. Smoking due to the abnormal increase in the height of oil level in the crank case on account of gasoline working into the base of the motor.
9. Excessive carbon in cylinder.
10. Tendency to overheat, due to lack of lubrication.
11. Very poor or no compression.

All of the above result in lack of power and poor performance. This diluted mixture tends to soften the carbon and practically makes a carbon-gasoline lapping compound which has a tendency to aggravate the wear already caused by parts running without adequate lubrication.

To eliminate so far as possible the above conditions:

1. Keep motor free from carbon.
2. Replenish regularly the oil supply in the engine base. For trucks in constant service this should be done every week in cold weather, decreasing to once a month in the heat of summer.
3. Use choke sparingly.
4. Do not adjust carburetor to give a rich mixture. This helps in starting, but the excess fuel eventually finds its way to the oil reservoir. Always make carburetor adjustments after the motor has run for some time and is thoroughly warmed up.
5. Use best grade of gasoline obtainable, especially in cold weather.

JOB 71. CLEANING VALVE STEMS; AND GUIDES, AND PISTON RINGS.

Due to the oily, gummy carbon-like deposits around the piston rings and about the valve stems and guides, it is a good plan to treat these points with kerosene each thousand miles of service. To do this will insure better power, compression, and lubrication, fewer repair bills, and smaller gasoline and oil bills. This operation may be carried out as follows:

1. Do this work just before draining the oil as indicated in Job 72. This is in order to prevent an undue waste of engine oil since it is necessary to drain the oil after the process indicated here is finished.

2. Open up the auxiliary air valve, or carburetor, in such manner that the end of a rubber tube or of the oil gun may be inserted. With the engine operating under its own power the oil gun is used to feed kerosene into the carburetor just as fast as the engine will take it without choking and stopping. If the engine tends to stop, the throttle should be opened and closed rapidly, which operation will likely keep it running until the kerosene has been worked through the engine. Run from one quart to two quarts through the engine in this manner, depending on the number and size of the cylinders.

3. Remove the inspection plates. Spray or squirt the kerosene onto and

into the valve guides, valve springs, tappets and tappet guides, working down and out the old grease and loosening the gummy accumulations about the valves and guides.

4. Clean all surplus oil from the tappet compartments, and clean up the engine where the kerosene and oil have run over.

5. Replace the inspection plates, after they have been cleaned and freed of dirt and grease.

6. Proceed to drain, oil and flush the crank case as directed in the next job sheet.

JOB 72. GENERAL INSTRUCTIONS FOR DRAINING, FLUSHING AND REFILLING THE ENGINE CRANK CASE.

It is impossible to sufficiently emphasize the need of proper care of the engine oiling system. New cars and even used cars find their way into the repair garage much more frequently than would be necessary if the oiling systems were cared for according to the directions of the car manufacturer. Not all engines may be drained, flushed and refilled in the same manner. Two examples are given in Jobs 73 and 74. These directions are according to the specifications of the manufacturer in each case. In the one the engine is to be cranked with the kerosene in the engine, in the other the motor is not to be cranked with the kerosene in the crank case. Wherever possible to obtain the car manual it should be followed most carefully.

In every case it is absolutely essential that the old oil be drained and the crank case flushed and washed out with kerosene once for each thousand miles of service. Where the car manual is not at hand the following directions may be safely followed:

1. Warm up the engine a bit to get the old oil flowing.
2. Remove drain plug and drain off oil into a bucket.
3. By shaking the car it is frequently possible to run out additional oil, after it would otherwise have stopped flowing.
4. Replace plug in drain.
5. Pour in from two to four quarts of kerosene.
6. Either run the engine under its own power, for 30 seconds at a slow speed, or operate it with the starter for a like space of time, or by placing one foot on each horn of the frame the mechanic can so use the weight of his body as to get the engine swinging up and down in such a manner that the kerosene will be splashed over the interior parts of the engine and wash down a considerable amount of dirt accumulation. (Use care to protect the paint in this operation.)
7. Remove the drain plug again and drain off the kerosene. Shake the car by the above mentioned method to keep the dirt from settling while the kerosene is being drained.
8. Allow the drain plug to remain out while the new supply of oil is slowly poured into the oil filler tube.
9. When the oil starts to flow clear and without signs of any more kerosene the drain plug is replaced and the engine filled to the proper oil level.
10. Where oil strainers are in use they should be removed each one thousand miles and thoroughly cleaned.

JOB 73. DRAINING OIL FROM PACKARD ENGINE.

Drain and flush the crank case of the Packard Twin Six each 500 miles in the winter and each 750 to 1000 miles of service in the summer months.

1. Remove the oil plugs from the bottom of the crank case and from the oil pump housing.

2. After the old oil is all drained off the crank case is flushed out by running kerosene through the oil filler.

3. Thoroughly clean the oil pump and strainer but do not run engine.

4. After the kerosene has been drained the crank case should be filled with two and three-fourths gallons of oil which is the amount required to bring it to the oil pet cock level.

5. Do not fill above the oil pet cock level.

JOB 74. DRAINING OIL FROM HUDSON ENGINE.

1. Remove the drain plug from the bottom of the oil reservoir, draining off all old oil. Shaking the car will frequently bring down more oil after all has seemed to have drained. Note Fig. 209.

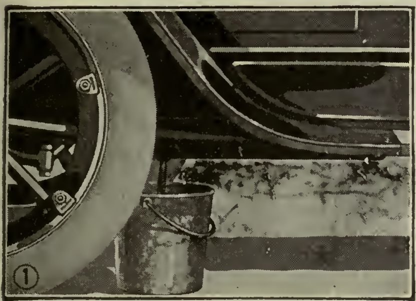


Fig. 209. Draining off Dirty Oil.

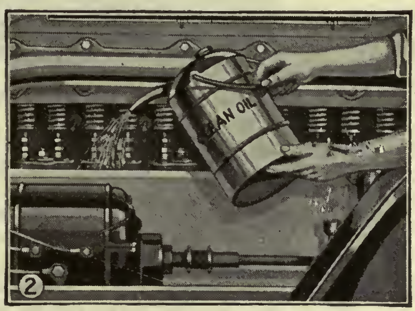


Fig. 210. Pouring in Kerosene (Hudson).

2. Remove the valve cover plates and pour about a quart of kerosene into each tappet compartment. Fig. 210.

3. Crank the motor with starter for about 30 seconds. Do not allow the motor to operate under its own power. This will wash down all sediment and dirt from the inside walls and oil troughs.

4. Remove the drain plug and drain off all kerosene, allowing at least 3 minutes for draining.

5. Pour clean oil into the tappet compartments. As this oil is poured into the compartment slowly, it runs into the oil troughs and displaces the kerosene left from the previous operation. This kerosene is allowed to flow out of the drain before the drain plug is replaced. The plug is only replaced after the lubricating oil starts to flow from the drain in a clean stream.

6. Refill with seven quarts of clean new oil.

JOB 75. CLEANING AN OIL PAN.

Even with the care given an oiling system as suggested previously, the continuous use of the car from month to month and season to season will cause an accumulation of dirt and sediment in the oil pan which is difficult to remove without actually removing the crank pan or oil pan. This is an operation for which only general directions can be given.

1. Remove the pan bolts and drop the pan down, having first drained away the oil.

2. Take the pan to the bench or cleaning trough and carefully remove the sediment, and clean each and every nook and corner.

3. Blow out the oil passages and make certain that nothing impedes the flow of oil through them.

4. Clean the oil strainers and any other parts attached to the pan.

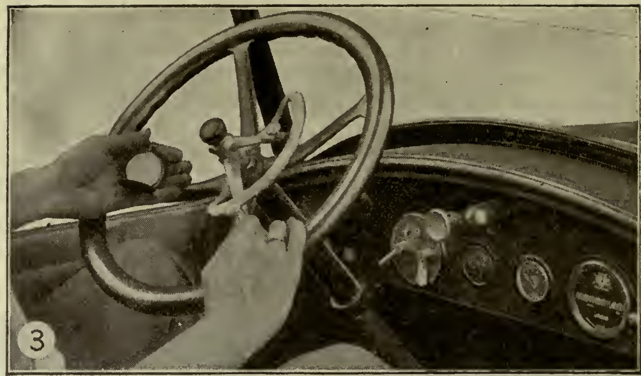


Fig. 211. Cranking Motor 30 seconds (Hudson).

5. Use compressed air to blow out all oil lines left on the engine.

6. Inspect and clean the interior of the engine. Wash out with kerosene. See that all oil holes to bearings are clean and free.

7. If the bearings are loose they should be put in shape at this time; however, the need of bearing adjustment is postponed indefinitely in many cases simply by properly caring for the oiling system.

8. Replace the pan and make all connections as formerly.

9. It may be necessary to use new oil pan gaskets to insure a tight joint.

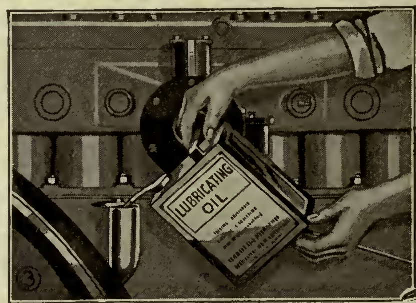


Fig. 212. Refilling with Clean Lubricating Oil (Hudson).

CHAPTER 8

COOLING SYSTEMS

There are two types of air cooling systems in use today. These are direct and indirect.

Direct Air.—The Franklin is the best example of direct air cooling. Here the air is drawn in through the hood, passes into a chamber over the cylinders, then down along the cylinders which have cooling vanes cast on them, and is thrown off or out at the rear of the engine through the flywheel fan. The cooling is more or less

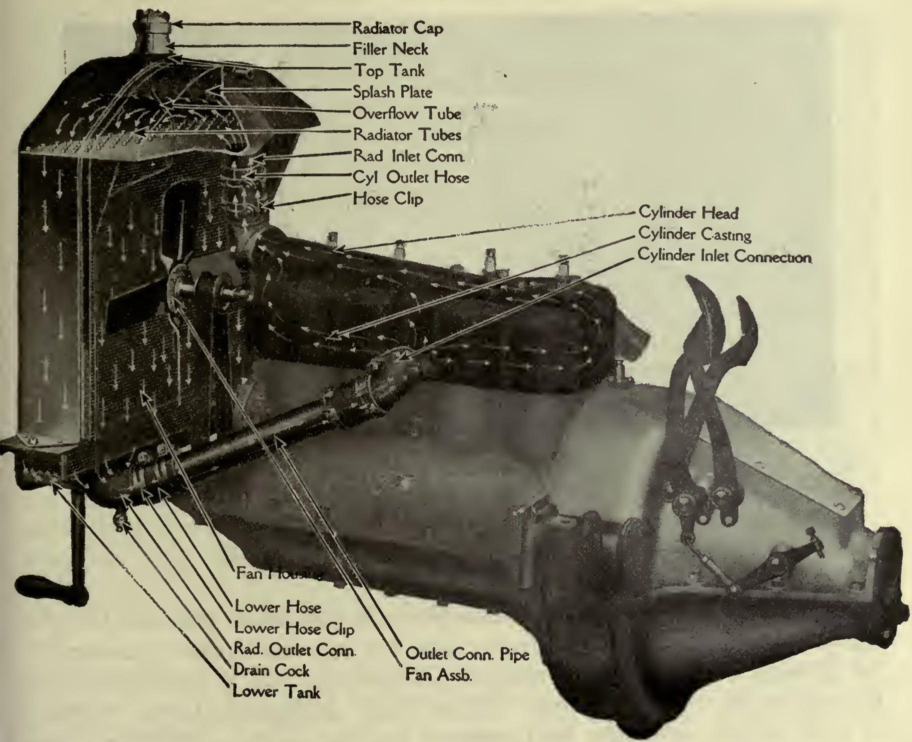


Fig. 213. Ford Thermo-Syphon Cooling System.

independent of the car speed, being controlled almost altogether by the engine speed. Low speed gear work does not seem to overheat the motor as is often the case in the indirect air-cooled systems.

Indirect Air.—In this case the engine cylinders are jacketed to carry a supply of water. The main supply of water is carried in the radiator. As the engine is operated the water around the cylinders is heated, after which it is circulated upward to the top of the

radiator, from which point it is passed downward through the radiator tubes, or cells, and the heat, extracted from the cylinder walls by the water, is now extracted from the water by the air in contact with the large surface area of the radiator cells or tubes and vanes. When the cooled water has come to the bottom of the radiator it is again passed or circulated upward through the cylinder blocks where it is again reheated, thence on to the radiator where it is recooled; and so on as long as the engine is running. In this system the water is used as a medium of transmitting the heat from the engine to the air, instead of having the air come in direct contact with the engine cylinders.

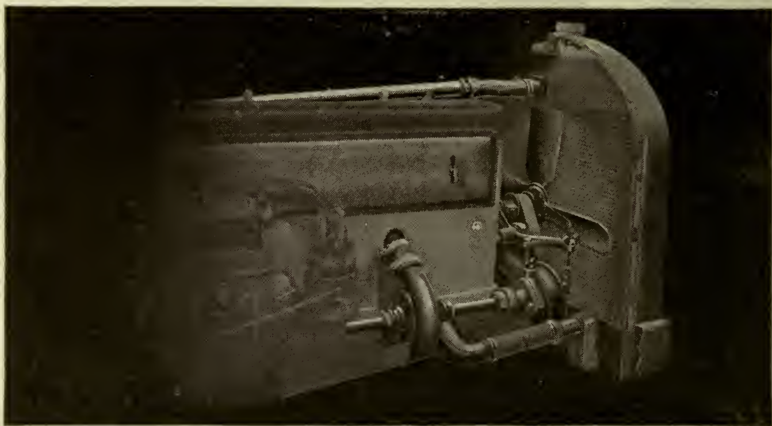


Fig. 214. Buick Cooling System.

Water Cooling.—The indirect air is known as a water cooling system. Here again we have two general classes, each with its peculiar advantages.

Thermosiphon.—The thermosiphon is the most popular for the lighter cars. Its use does away with the necessity of a pump with its attendant parts and troubles. Circulation here is established by the action of a natural law. When water is heated, those portions of it in contact with the heat expand, become lighter, and rise to the top. Portions on top and cooler will settle where they in turn are heated to a point above that of the water now on top, when it is displaced and returned to the bottom for more heat. Circulation is continuous so long as heat is applied. The word "thermo" meaning heat, and "siphon" to draw out, might be said in this instance, to mean, to draw out the heat from the engine. To facilitate a rapid circulation in this case, the radiator inlet and outlet is made large. An advantage of this type is that an engine will warm up more readily

than one where the pump is used, as the water does not start circulating until it is heated. One disadvantage is that the water may freeze, in cold weather, in the lower parts of the radiator before circulation is fully established.

Forced or Pump Circulation.—In this case the water circulates in the same manner as in the thermosiphon, but a mechanically driven pump is used to keep the water circulating. The pump is used to draw the water from the lower part of the radiator and force it into the lower part of the cylinder block, from which point it follows the usual path. Circulation is established immediately and positively. Smaller water connections and hose are used than in the case of the thermosiphon.

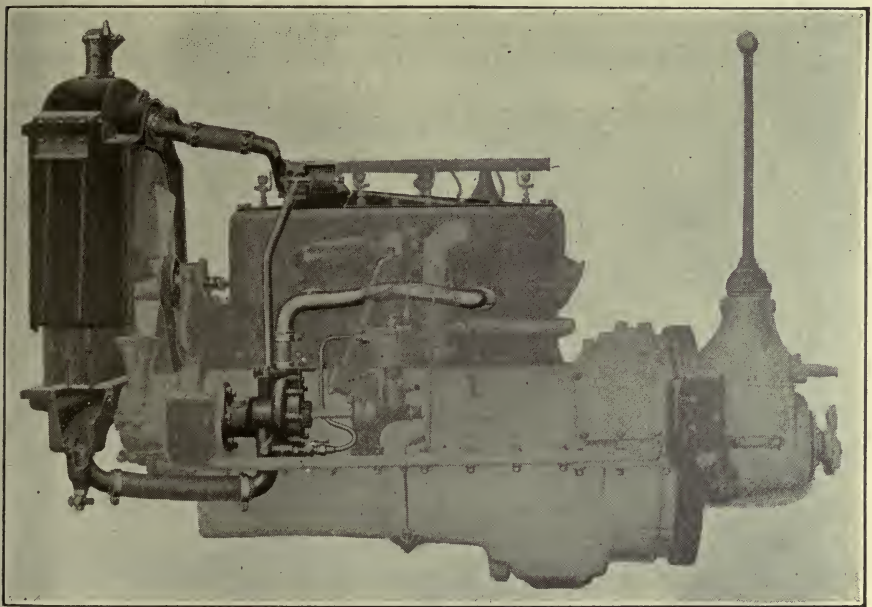


Fig. 215. Packard Truck Cooling System. Note the thermostatic control which keeps the water passage to the radiator closed until the water within the cylinder block has come to a temperature allowing efficient operation of the engine. As the engine continues to run after reaching this point in temperature the thermostat gradually opens until sufficient water flows to keep the engine at this point of greatest efficiency.

Cooling System Care.—The careful driver or mechanic never fails to give the cooling system daily inspection. Usually a small quantity of water daily is sufficient to keep all working smoothly. The sudden and unusual disappearance of water means trouble; it may mean a leaky radiator hose connection or something more serious, as leaking cylinder head gaskets, a broken or damaged radiator, or other parts. Whatever the trouble is, it should be located and remedied immediately.

Radiator Hose.—Owing to the fact that the automobile is in use on uneven as well as smooth surfaces, there must be a degree of flexibility between the various units. To permit this movement between the radiator and engine, rubber hose is used to form the water connection. Hose bands or clips are used to bind the hose in position. Occasionally shellac is used to make a tight joint, but should not be used unless the leak cannot be stopped otherwise.

Rubber Hose Troubles.—Due to the moisture, heat, vibration, bending and twisting to which the hose is subjected, it will wear out and need to be replaced occasionally. Length of service is no indication of condition. The hose may last two weeks, two months, or two years. One year may be a conservative average. Usually the hose peels away on the inside first, and this inner rubber lining breaking lose may cut off all circulation through the hose. Again it may be carried into the vital parts of the circulating system and clog

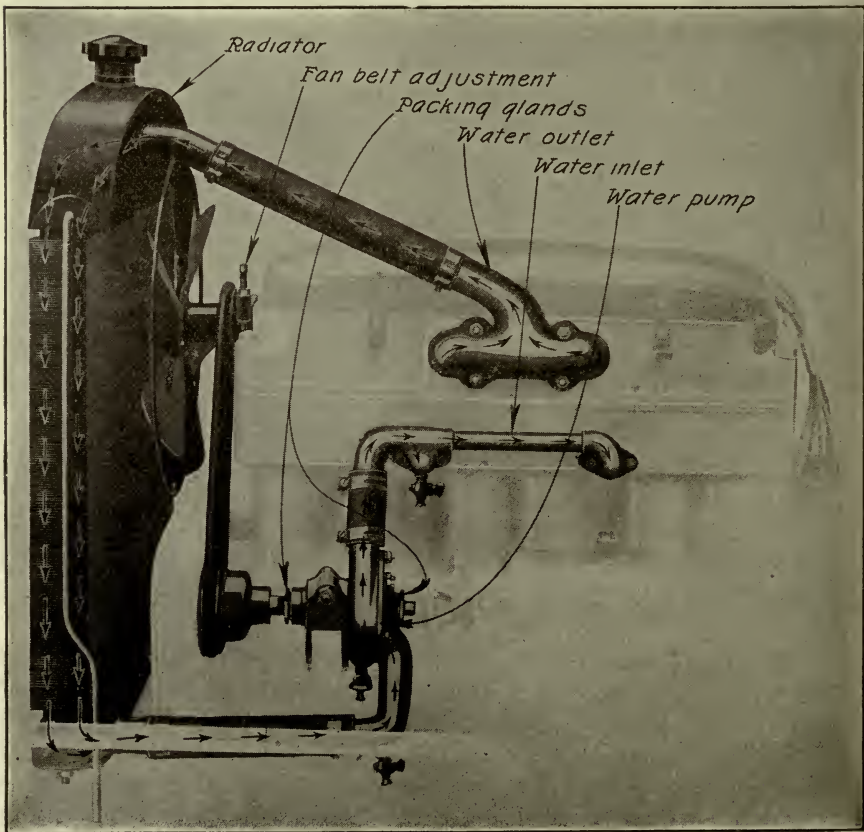


Fig. 216. Reo Water Circulation System. Arrows indicate the direction of flow of the water.

them. Naturally less resistance is needed to retard circulation in the thermosiphon system than in the forced circulation.

Steaming Radiator.—This is an indication of lack of water or failure to circulate. Failure to circulate may be due to a frozen radiator or passages, or a broken down rubber hose or pump. If a radiator filled with water starts steaming on a cold day the trouble is obvious, likewise the remedy. Leaving the car set with the radiator covered will often thaw out the troublesome spot. If this does not avail, it will be necessary to get the car into a warm garage.

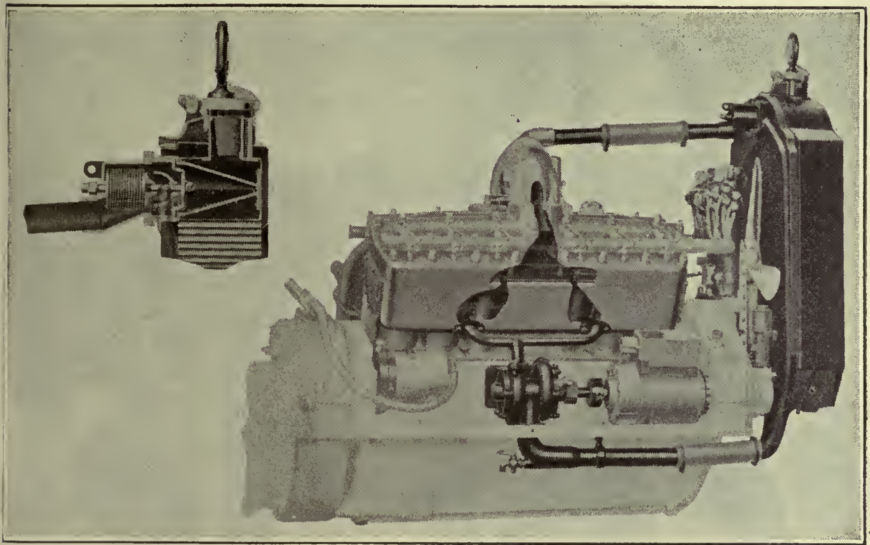


Fig. 217. Packard Twin Six Cooling System. Thermostat in Detail.

If the trouble is in the hose it may be detected sometimes by exerting pressure on the outside of the hose. This is not always true however and the hose may have to be removed and inspected. When this fails, inspect other parts. The impeller on the pump shaft may have worked loose, or other mechanical trouble may have developed. A systematic search must be made and the trouble corrected.

Radiator Mountings.—To prevent unusual jars and twists being transmitted to the radiator, springs, swivels or buffers of some kind are provided. A radiator not so provided, as in older types, may be protected by having a piece of rubber mounted under the supports.

Radiator Types.—In designing radiators having large surface areas exposed to cooling drafts of air as it is drawn through the radiator core, several distinct types have been developed. Very thin copper is used to construct the vanes and tubing or cells, to insure

rapid radiation of the heat from the water. The types in use are the tubular and the honeycomb or cellular.

Tubular Type.—This is the most common type of radiator. Usually round tubes are used. To assist in rapid radiation of the heat from the water as it passes down through the tubes, they are mounted in thin metal vanes or fins. Air passing over these fins cools them relieving them of the heat they receive from the tubes. In this construction the tubes run from the top straight to the bottom. Tubular radiators are constructed from flat tubes, from corrugated

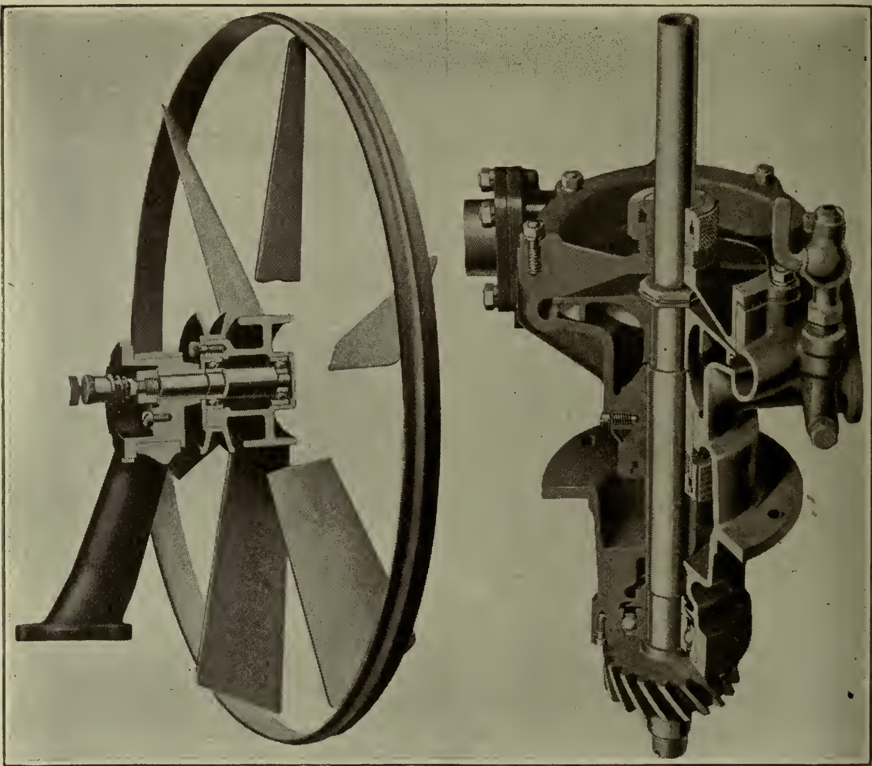


Fig. 218. Packard Truck Fan in Section.

Fig. 219. Packard Truck Engine Water Pump in Section.

tubes, and tubes of many styles. In some cases they are straight and in others they are bent into such shape that when mounted they resemble the honeycomb but are not true honeycomb types.

Honeycomb or Cellular Type.—This type is of more delicate construction, is more expensive, and generally considered a little more efficient. Tubes of round, square, or hexagonal cross section, are mounted in a core with the cells a slight distance apart, the ends opening towards the front and rear of the radiator. The air passes

through the tubes or cells, while the water is passed around them in its flow from the top to the bottom of the radiator. In the tubular type the water passes through the tube and the air around it, or just the reverse of the honeycomb or cellular.

Radiator Troubles.—As a rule, the apprentice or mechanic is not required to make more than minor repairs on a radiator. He should feel no hesitancy in making the repairs, such as soldering a superficial break or a loose overflow tube or making any repairs where the trouble is easily reached. Badly damaged radiators should be turned over to the radiator repair expert or replaced with new ones. To make an efficient repair on a badly damaged radiator requires special appliances and equipment for doing the work, as well as making proper tests.

Types of Pumps.—Gear pumps similar to the oil gear pumps, rotary pumps similar to the rotary oil pump, and centrifugal pumps are used for circulating the cooling water. The last named is most generally used. This pump is designed on the same principal as any centrifugal pump. The water is taken in near the center of the pump case or impeller hub. The impeller turning causes the water to be thrown to its rim, where another opening is provided to permit it to escape into the other parts of the circulating system. Advantage is taken of the natural flow of the water.

Pump Drive.—The timing gears are usually used to drive the pump. The pump shaft runs through the pump case to the distributor, generator, or whatever other units of equipment it is desired to drive. The Oakland deviates from this practice by driving the pump with the fan belt.

Pump Troubles.—As a rule a pump gives little trouble, but the packing nuts on the shaft are in need of care to prevent them from leaking. It is good practice to place a grease cup on each pump bushing, or bearing, in which graphite grease or cup grease is used. These should be turned up regularly to keep grease in the bearings. If water starts working through, rust develops, the shaft becomes pitted, and it will be impossible to prevent leaking as the packing will wear away as fast as replaced. When there are no turns left on the packing nut, it will have to be backed off, (one is a right-hand thread, the other left, and both turn off counter to the direction of drive of the shaft), and new packing substituted for that worn away. Replace with pump packing furnished by the manufacturer, if possible. If this is not available, hempen cord well graphited and wrapped on the way the nut turns will make a more or less permanent repair.

Impeller Troubles.—Occasionally, after considerable service, the pump bushings may wear away permitting the impeller blades to strike or rub on the pump case. This will cause wearing and trouble

in time, such as loosing the impeller on the shaft. It will be necessary to remove and rebuild the pump in a case of this nature. A point of prime importance is to have the impeller assembled on its shaft correctly to throw out, or pump water.

Cooling Fans.—A fan is mounted just back of the radiator core and used to draw, through the core, the air needed to carry away the heat radiated from the water coming from the engine jacket. The fan is of more importance when the car is standing, with the engine operating, than when being driven. In driving the air is forced

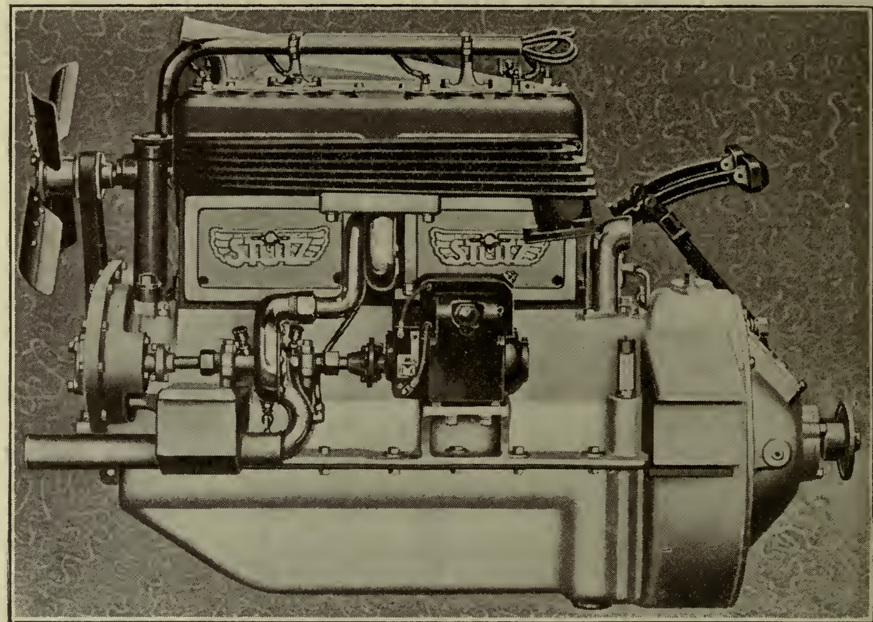


Fig. 220. Stutz Cooling System. Note fan and fan belt adjustment, also fins cast on the exhaust manifold as an aid in cooling.

through by the speed of the car as well as the draught of the fan. The fan is also more essential on low and intermediate gear speeds than on high.

Fan Care.—Other than keeping properly lubricated and belt tight, little attention need be given the fan. If ball bearings or roller bearings are used, a few drops of oil every thousand miles will suffice. If bronze bushings are used the grease cups will need to receive the same attention as other grease cups.

Fan Belts. — Since flexible drive is used on fans, the proper tension must be kept on the belt. Too loose permits too much slippage, while too tight prevents any slippage and causes wear on bushings if these are used on bearings. A fan delivers most air at certain fixed speeds and not a corresponding amount always with the increase of speed. For instance, the Liberty Motor gives most

power at 1800 R. P. M., the propeller gives most power at 1400 R. P. M. This leads to the use of reduction gears to obtain the proper working speed for each. Some manufacturers introduce a friction joint in the hub of the fan to permit of some automatic adjustment of the speed to the power. A loose or broken fan belt will permit the engine to become overheated and a steaming radiator is sometimes the result. Tighten or replace with a new belt.

Fan Belt Adjusting.—An adjustment for the fan belt is always provided; loosening the set screw and swinging the eccentric arm until proper tension is obtained, then resetting the screw is all that is needed to take up the belt slack. In placing on a new belt, provision should be made for future tightening.

Changes of Temperature.—If the car was always operated at a fixed engine speed with the temperature of the surrounding atmosphere always at a fixed point, it would be a comparatively simple engineering feat to design cooling apparatus which would keep the motor at just the proper temperature for efficient operation (170 degrees Fahrenheit). Since the temperature of the atmosphere, which is the real cooling medium, varies as much as 130 degrees Fahrenheit at different seasons of the year, in some communities, it is necessary for the designer to provide for the average temperature, and to arrange special features to take care of extremes, especially extreme low temperatures.

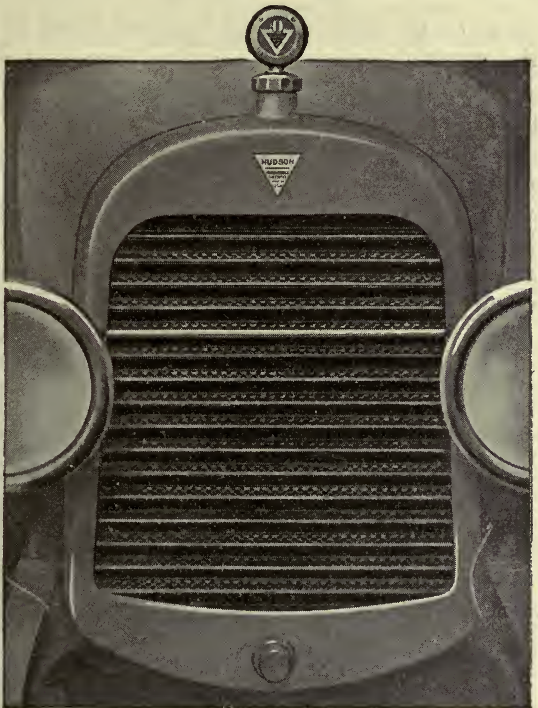
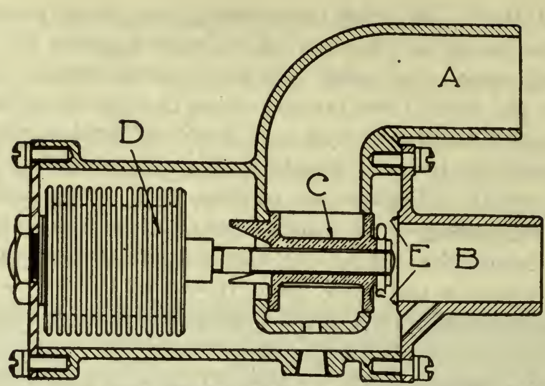


Fig. 221. Radiator Equipped with Shutters. This permits of readily controlling the heat of the engine. A hand control for the shutters is provided on the dash. Shutters in Horizontal Position When Wide Open.

In the summer it is sufficient to have the fan belt properly adjusted, radiator properly filled, ventilating shutter and covers open. In some extreme cases remove part of the hood or floor boards, in case of truck engines give them every possible chance for cooling.

In the winter, however, provisions must be made to shut out



Cross Section Thermostat Arrangement. A, Radiator coupling; B, By-pass coupling; C, Piston valves; D, Thermostat; E, By-pass seat.

Fig. 222. Diagram of Thermostat mechanism.

some of the cold air, and in come cases to control the circulation of the water.

Hood and Radiator Covers.—In some cases manufacturers are providing a ventilating shutter for the hood, which may be controlled either by a thermostat or a dash control. The Hudson is a good example.

Thermostat Control.—In other cases manufacturers are providing thermostatic control of the water circulation: A thermostat in the water pump intake pipe controls a valve which permits the water to circulate through the cylinder jackets so that the engine is operat-

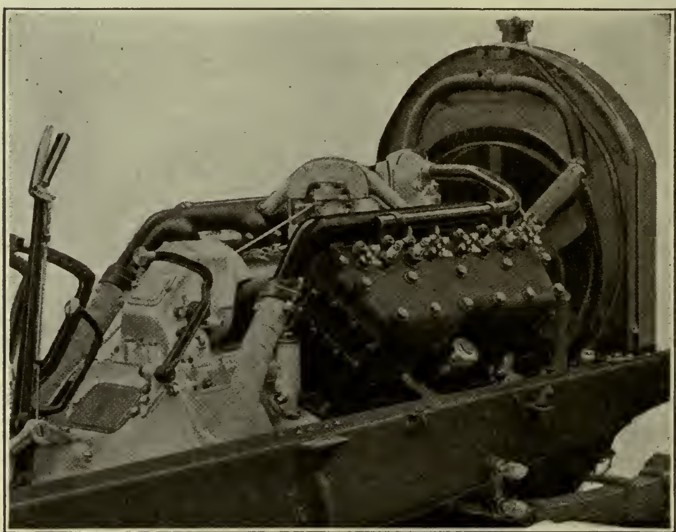


Fig. 223. Cadillac 8 Engine.

ing at the most favorable temperature at all times. The thermostat D in Fig. 222 is made similar to an accordion and is filled with a liquid which vaporizes on being heated to a certain comparatively low temperature. The pressure that this gas exerts on the retaining walls of the thermostat causes enlongation of it and this action in turn operates the valve C which permits the water to flow from the radiator.

The water is not permitted to circulate from the radiator to the engine until that in the water jackets and pumps and the bypass has been brought to the correct operating temperature. When this has been accomplished the thermostat gradually opens the passage to the radiator.

Cooling Solutions.—Radiators need but little care in the summer except occasional drawing off of water and flushing out to prevent sediment obstructing circulation. In winter, in addition to this, the use of a non-freezing solution is recommended to prevent freezing and consequent injury of parts. Water alone will do very well when warm garages are used providing the radiator can be prevented from freezing while the car is in use. This is rather difficult unless all parts exposed are carefully protected from cold drafts of air, as for instance, the lower water passage from the radiator which frequently freezes, due to the cold draft striking it. A radiator usually freezes on the bottom first when the car is in operation, and on top first if standing in a cold place for any length of time.

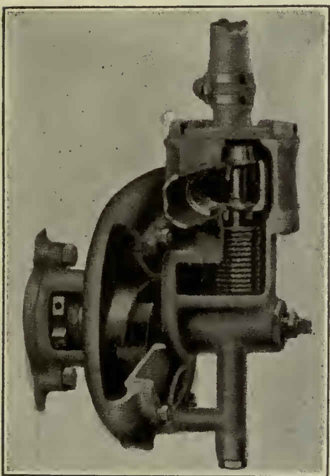


Fig. 224. Cadillac 8 Pump.

Non-Freezing Solutions Recommended.—The best solution to use is wood alcohol. Denatured grain alcohol is second as it will require a greater quantity than of the wood alcohol, with a corresponding reduction of temperature of the solution. Alcohol and glycerine is ranked perhaps as second choice after the alcohols. The glycerine having a high boiling point counteracts the low boiling point of the alcohol One bad feature of the glycerine is its tendency to attack rubber, but this tendency is offset to a certain extent by the alcohol. Glycerine is also more expensive to use than alcohol.

Calcium chloride solutions are very largely used. They form the nearest ideal solution in point of reduction of freezing temperature and low boiling point, but there are several points which make their use somewhat risky. The solution is acid by nature and acids are

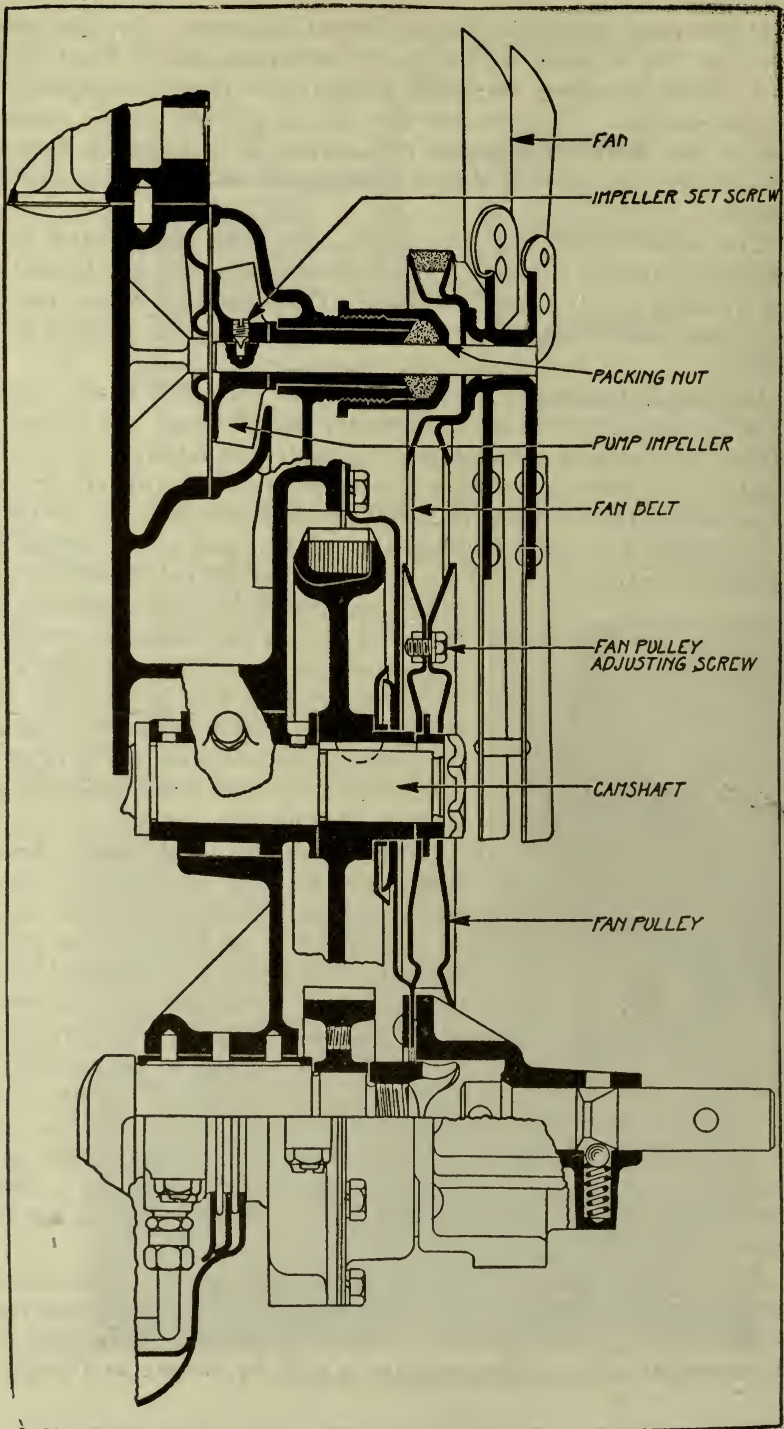


Fig. 225. Note Double Bladed Fan Construction and method of drive.

known for their ability to corrode, eat away and destroy certain metals. It is necessary to have the acid neutralized by the addition of soda ash or some other alkaline substance. When properly neutralized the solution is not supposed to be particularly dangerous. To test, place a piece of the blue litmus paper in the solution. If it

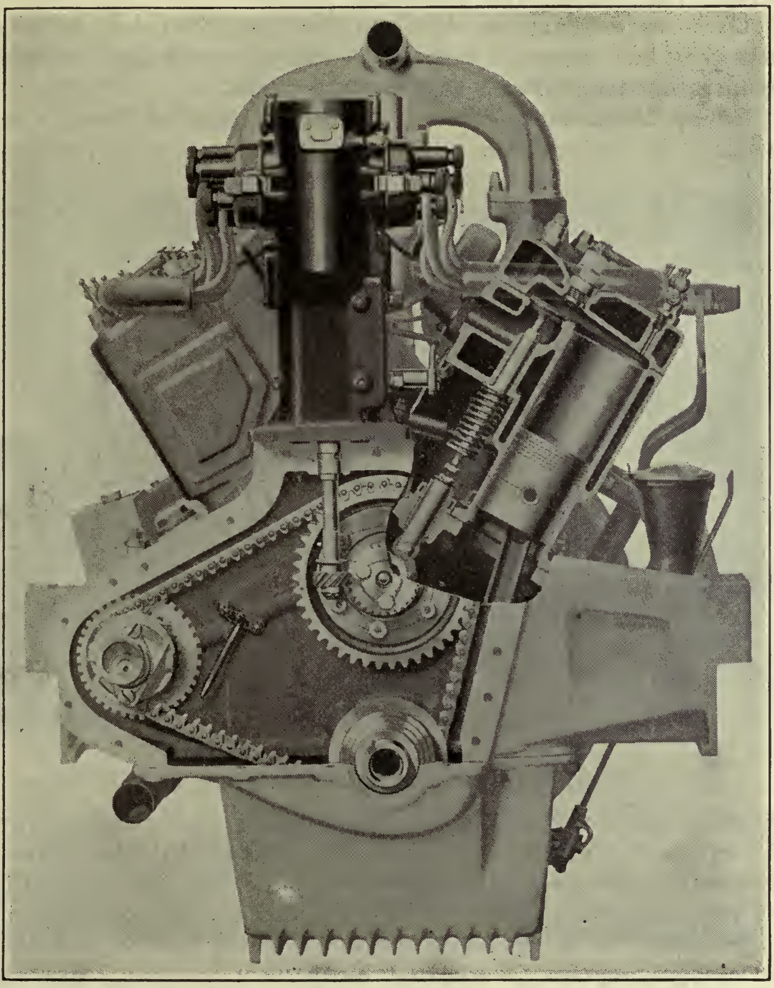


Fig. 226. Packard Twin Six in Section. Note fins cast on bottom of crank case or oil pan. These assist in keeping the lubricating oil cool.

turns red, free acid is present and more soda ash should be added. A large number of brands of the calcium chloride preparations or similar substances are on the market. Some are particularly harmful to aluminum parts, and if used in a cooling system having an aluminum pump case for instance, it will so eat it or pit it as to make

replacement necessary. Manufacturers of this type of product are rather conscientious, and if directions for the use of their product are followed, little trouble need be expected. It might be worth the student's while to know, too, that since the solution is acid and comes in contact with metals of various kinds that electrolytic action is likely to take place, thus weakening joints.

Over Heated Motors.—In order that the driver may know at all times that his engine is not overheating, various devices showing the operating temperature have been perfected.

Boyce Motometer.—This is the most popular device for the purpose. A thermometer is arranged to show the driver the safe

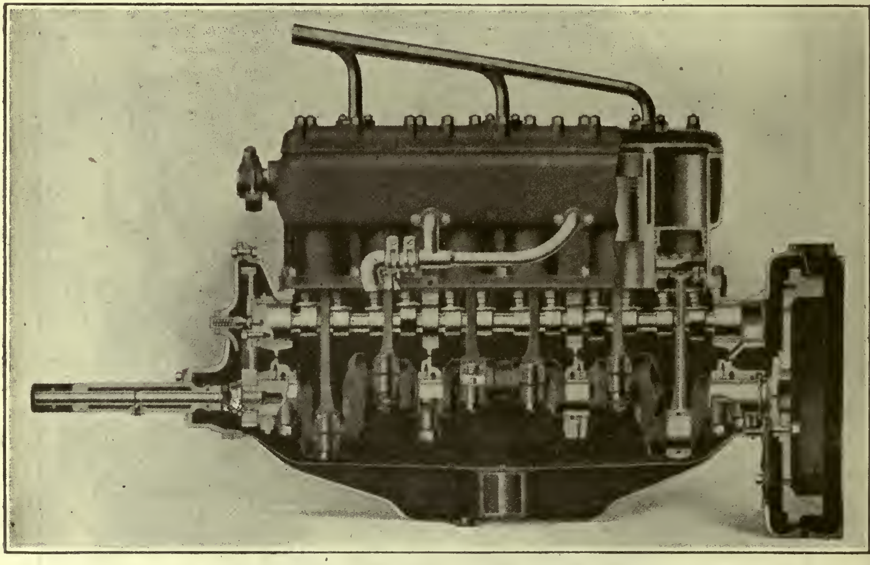


Fig. 227. Continental 7R. Note water jackets around cylinder.

operating temperature and the danger point as represented by the heat within the radiator. The danger here is that the driver may become so accustomed to the perfect operation of his engine that he will not notice a sudden rise of the mercury or approach of the danger point.

Recognizing An Overheated Motor.—The careful experienced driver needs no special device to tell him his engine is overheating. His ear has become so attuned to the natural hum of his engine that any unusual sound is quickly recognized. Overheating will give rise to these unusual sounds, the main one of which is a pounding or knocking sound, as in overloading the motor on a heavy grade on a hot day. Instead of a smoothly running sound the engine seems to labor, to give out a harsh more grinding sound as of parts running

without lubrication. This is very likely to be true as the oil is likely thinned out and burned up due to the unusual heat. Steaming at the radiator filler cap and the sound of boiling water may or may not be noticed.

Causes of Overheating.—Hot weather is perhaps the most frequent cause of overheated engines, as it has such a direct effect on the cooling of the water in the radiator. This need not result in burned out bearings or scored cylinders if due care is exercised to have the cooling system in good condition, as having the fan belt tight and the radiator cleaned of all dirt and sediment and properly

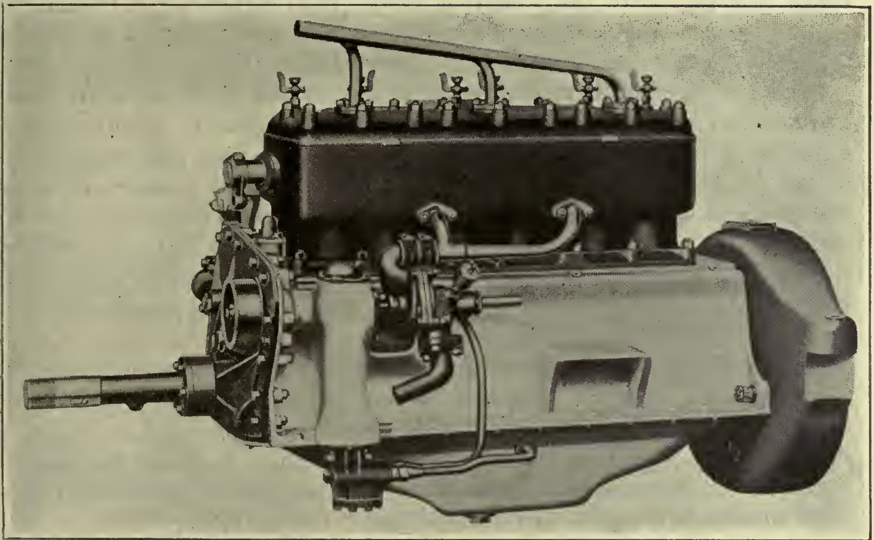


Fig. 228. Continental 7R. Note Water Pump, Oil Pump and Fan Adjustment.

filled; also the oiling system in good condition and an oil of the high flash test in the engine. Needless to say, the oil must be clean and free of carbon or other foreign matter. Refer to the chapter on oiling systems to get the essential points.

Cooling the Overheated Engine. — Ordinarily the overheated engine will be quickly cooled if the bad stretch of road is passed and the engine relieved of its overload, as topping the bad hill and coming onto a level stretch. Here the air rushing through the radiator will quickly right the trouble. This cannot always be done as in pulling through bad gravel, mud and sand, or climbing long heavy grades. Then it is best to allow the motor to stand idle until the water has had a chance to cool off the engine. Raising or removing the hood will always help.

Filling An Overheated Engine.—In the overheated engine the water in the radiator may have boiled away so that it will need refill-

ing. The great danger here is that the sudden introduction of cold water on cylinder walls, heated to a red hot heat in some cases, may cause them to suddenly contract and crack, thus making their replacement necessary. If there is any likelihood that the water is all gone from the cylinder blocks, time must be given to allow the extreme heat to be radiated and then water added very slowly.

Non-Leak Solutions.—The radiator being made up from so many thin parts and subjected to constant jars, hammering, twisting, and straining, small leaks are likely to develop. These are likely to occur in either new or old radiators and often are in places very hard to reach to repair with the soldering iron. It is sometimes advisable to use a non-leak solution in the radiator. All serious leaks should be soldered if the repair is to be made permanent.

Use of Cereal Preparations.—Plain cereals such as corn meal, ground flax seed, bran, etc., will serve as a temporary repair even in a rather serious leak and a knowledge of the fact may enable the driver to get out of a very trying situation. The practice is to be discouraged as a general thing since the excess will settle in the radiator, or in the water jacket, and tend to obstruct circulation and radiation. These cereals clog the leak because in attempting to pass through they are caught and as the water affects them they are swelled to fill the opening.

Use of Liquid Preparations.—The liquid preparations may be recommended more highly. X liquid (a trade name) is a good example. It is placed in the radiator with the water. The solids in it remain in solution indefinitely, unless they are carried out or steamed out through the leak, when they are left in it, or on it as a hard insoluble deposit. In a short time, ten or twenty minutes, the leak will be sealed. To facilitate the heating of the water it is well to cover the radiator for a time. This solution cleans the radiator of scale and is claimed to be beneficial in this respect.

Cleaning the Radiators.—All radiators must be flushed out occasionally. A strong alkali such as soda will remove scale and tend to seal small leaks.

JOB 76. RADIATOR HOSE CARE.

The radiator hose connections are very frequently the source of trouble. Leaks develop around the hose bands and the rubber disintegrates on the inside stopping the flow of the water.

1. To stop a leak about the hose, use a screwdriver to draw the clamp bolt tighter.

2. Failing this, it may be necessary to renew the clamp if it should be found in poor condition.

3. The hose itself may be rotten or broken in such manner that it must be renewed.

4. If the hose is in good condition, and drawing on a clamp, likewise in good condition, fails to stop the leak, shellac may be resorted to. Remove the

hose. Coat the inlet with shellac and allow same to dry until tacky. Replace hose and tighten.

4. Where the hose must be replaced the first step is to release the clamp.

5. Grasp the hose in the hand and give a good pull and twist at the same time. If this will not loosen it the screwdriver blade may be used to run under the hose and thus work it loose.

6. Whenever the hose shows signs of breaking out on the inner lining or rubber it should be discarded.

7. In fitting the new hose it is not shellaced unless this is found the only means of stopping a leak.

8. Be very certain to avoid any kinks in the new piece of hose as it is applied. A kink interferes with the ready passage of the water. Particular care must be used to keep the passages free.

9. In adjusting the fan be very certain that the blades do not come into contact with the rubber hose. Sometimes a fan adjustment fails and the hose is cut by the blades.

10. It is a good plan to change the hose at least once each year.

JOB 77. RADIATOR CARE.

Since the water passages in the radiator are very small, it is quite essential that they be kept open. The use of any water bearing such matters as lime in solution will lead to a partial stoppage of the passages and overheating of the engine. To remove sediment collections it is well to flush out the radiator at least once each season and preferably every month or so. To do this proceed as follows:

1. Place the car on the washstand, or elsewhere, where the water may flow from the radiator and be carried off properly.

2. Start the engine running at a moderate speed.

3. Open the drain cock.

4. Place the end of the hose in the radiator and turn on the water. Allow the water to run into the top of the radiator just a trifle faster than it runs out of the pet or drain cock. The overflow tube will care for this trifle of excess and the water need not run over the outside of the radiator.

5. Allow the water to run with the engine running for from 15 to 30 minutes.

JOB 78. REMOVING A RADIATOR.

1. Drain the water. If a non-freeze solution is in use, save the solution for refilling.

2. Remove the engine hood.

3. Remove the stay rod if there is one.

4. Loosen the radiator bolts where the radiator shell is fastened to the frame of the car.

5. Loosen the radiator hose bands.

6. Make certain that the radiator hose is loosened from the water inlets on the radiator.

7. Lift off the radiator.

8. If it is desired to remove the radiator from the shell, this is done by removing the small bolts used in most cases to hold the two together.

JOB 79. TESTING A RADIATOR FOR LEAKS.

1. Remove radiator. (Job 78.)

2. Solder a piece of brass or other sheet metal over each of the outlets. (Hose connection pipes and overflow tubes.)

3. Fill with water. Turn on radiator cap.

4. Using a foot pump with air line slipped on over the drain cock, force in a slight pressure of air. Not over five pounds pressure should be used.

5. This will cause the water to run, or in cases of a decided leak, to be sprayed out from the points where the radiator is leaking.

6. Locate the several leaks and mark their position after which the radiator is soldered.

SECOND METHOD.

1. Place the radiator with all the outlets soldered shut into a trough or tub of water.

2. Force air at a pressure of not to exceed five pounds into the radiator noting the points at which the bubbles arise and marking them for repair by soldering.

3. In the case of a bad leak there may be no need of following either of the above methods as the leak is easily located before removing the radiator from the car.

4 After repairing, either of the above tests may be applied to learn the condition of the job.

5. If there is time, the radiator should be filled, placed in an upright position and left over night to learn whether or not the repair is complete.

JOB 80. REPAIRING A RADIATOR LEAK WITH A LIQUID COMPOUND.

The liquid preparations on the market for use in repairing radiators are all similar in nature. They are placed in the radiator and as they are steamed through the leaks they solidify on coming into contact with the air. They are safe to use. X-Liquid is a sample of this.

1. Drain and flush the radiator as recommended in Job 77.

2. Fill the radiator within a quart of full, using clean soft water.

3. Start the engine running. Make certain that the oil in the crankcase is up to the "full" mark.

4 Throw a blanket over the radiator leaving the filler cap off and the filler tube exposed so as to note when the water comes to the boiling and steaming point

5. Put in the required amount as directed on the container.

6 Continue to operate the motor until the radiator shows dry under the blanket. This is possible because of the fact that as the leaks are sealed the water ceases to seep through. Any water on the radiator is quickly dried off due to the fact that the water on the inside of the radiator is at the boiling point. Since the action of the compound is dependent on the heat, it is just as well and perhaps better to do the work on the floor where the temperature of the engine may be watched than it is to attempt to do it on the road when the engine may or may not reach the required temperature. If the engine is held at that speed which will just boil the water and the proper amount of oil supplied to it there is no danger of burning it out.

JOB 81. REPAIRING A RADIATOR.

1. Remove and test the radiator as indicated in Jobs 78 and 79.

2. Solder all the leaks appearing on the outer surfaces and about the reservoirs and overflow tubes. This work is readily done with the regular iron. Treat the parts with soldering salts or acid. If the solder refuses to take, wipe the part while still hot with a rag saturated with the acid. Continue heating and treating the parts until the solder does take. Of course, the major part of the dirt and corrosion is scraped from the parts before attempting to solder them, but even then difficulty is frequently experienced in getting the

solder to take and run properly. The acid steamed off the hot part will be of material help.

3. The soldering of the leaks on the inner parts of the core or tubes is an operation requiring skill and patience. Very frequently the large iron will not reach the point where the leak is. In such a case the workman must devise other means of bringing the heat to the point where it is needed.

4. A lead burning flame will do the work in some cases.

5. A safer method for the small leak is to use a piece of copper rod of a size suitable to get to the leak and make of it a soldering iron. In some instances the work can be hastened by using the lead burning or other flame on the outer end of this small rod, the heat then being conducted to the point through the rod. This does away with the trouble experienced in having the rod cooled so rapidly that the solder cannot flow.

6. In the case of certain cells of the cellular type leaking, it is sometimes possible to make a repair by soldering a small piece of sheet metal over each end of the cell. This is a repair recommended only for very old radiators or for temporary repair to hold until the repair can be brought to a radiator expert.

7. As a rule the radiator work of a serious nature should be left to the mechanic and shop well fitted and equipped for this class of work. The auto mechanic should attempt only those jobs which are rather easily reached.

JOB 82. OVERHAULING A WATER PUMP.

It very frequently happens that failure of the cooling system can be traced to the failure of the water pump. Where the pump is suspected proceed as follows:

1. Remove the pump from the engine.

2. Take it to the bench and open it up. Use care in this operation, noting carefully the proper relation of parts. In working on a water pump, difficulty is frequently experienced with screw threads due to the fact that the water has rusted them. Unless care is utilized, it is quite possible to have the set screws broken off in the castings.

3. Inspect all parts for wear, particularly the impeller. If this is worn considerably at points where it comes into contact with the case it should be replaced.

4. Inspect the shaft to see if the water has pitted and rusted it. Replace if necessary.

5. Inspect the shaft bearings which are of the bronze metal type in most instances. If worn badly, replace.

6. If the pump is generally in bad condition the entire unit should be replaced with a new one. Aluminum pump cases are particularly subject to the action of certain non-freeze solutions which cause the inside of the pump to be eaten away in an alarming fashion. The same is true of certain water supplies in which impurities are found.

7. The most frequent pump trouble is the loosening of the impeller on the pump shaft. Make this secure in reassembling the job.

8. Reassemble and replace the pump on the engine.

9. Test.

JOB 83. PACKING A PUMP.

The pump shaft very frequently runs through both sides of the pump case and is supplied with two packing nuts or bushings. These must be maintained in proper condition to prevent leaking.

1. Fig. 229 shows the National Sextet engine and pump. Directions are also given for tightening the nuts.

2. The nuts are always tightened by turning them in the direction of rotation of the pump shaft.

3. When the nuts have been turned all the way into the case they will perhaps no longer retain all of the water. In this case they will need to be repacked. It is better to repack than to attempt to force the nut a bit farther. This is likely to result in a broken pump shaft housing.

4. Back off the packing nuts.

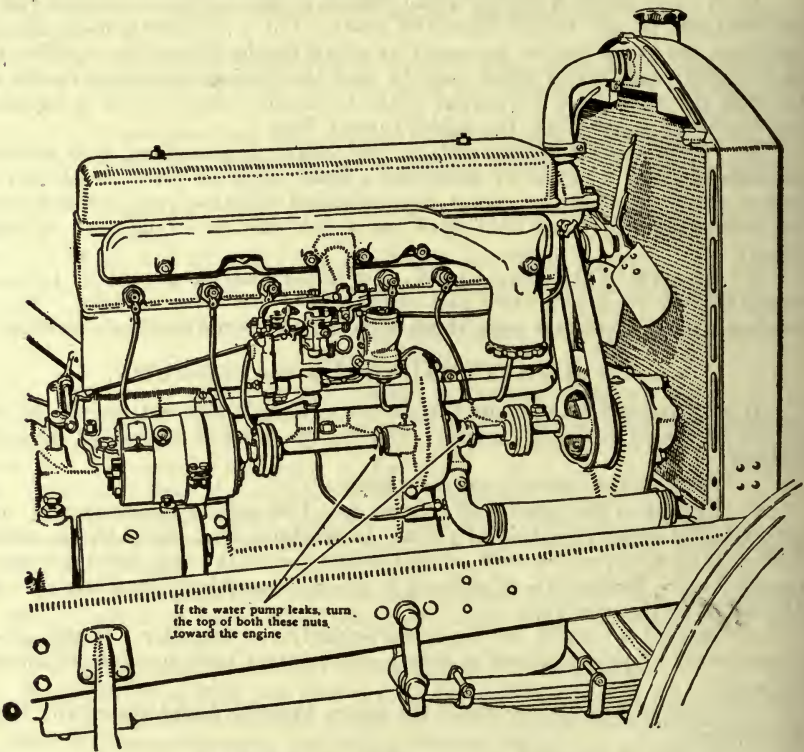


Fig. 229. Packing a National Sextet Pump.

5. Secure the proper pump packing from the car manufacturer, or failing this use some felt or woolen yarn to wrap the shaft with. Even hempen or cotton string may be used, although any packing to give the best service must not be too hard. Use graphite grease to pack the packing in.

6. Turn the new packings down snugly.

7. Operate the engine and then give the packing nuts a further turn.

8. See that the grease cups are properly filled and turn them down until grease starts oozing from the packing nut. If no leaks show, this should complete the job.

CHAPTER 9

FUEL SYSTEMS

GASOLINE SYSTEMS

There are three types of gasoline systems in general use. These are the gravity, pressure and vacuum. This applies more especially to the method of bringing gasoline to the carburetor from the main supply tank. More recently, however, the term gasoline system has come to mean all methods and units or parts used in storing, feeding and supplying the fuel to the engine ready to be compressed.

Gravity System.—This system was formerly used very extensively on both trucks and passenger vehicles. The vacuum system has largely replaced it for passenger car use. For this system to work satisfactorily it is necessary that the supply tank be placed at a point considerably higher than the carburetor. As gasoline is drawn from the carburetor, more is permitted to flow from the supply tank to the carburetor bowl through the feed line. The tank is either carried on the dash under the front seat, or on the deck as in the case of the roadster or speedster. The supply tank in this case need be only of medium strong construction. The cover must always be provided with a vent to permit air to enter as gasoline flows out to the carburetor. This vent must be of such a nature as to prevent the gasoline being splashed out.

This system is pretty certain to require a low hung carburetor and a long intake pipe, especially so where the tank is placed under the seat. In the case of the tank under the cowl it has the disadvantage of having the tank immediately in front of the driver and very close to the engine. This is likely to result in poor body design. The fumes from the gasoline are frequently annoying to passengers. Dirt and grease will accumulate about the tank due to frequent fillings. Since the instrument board is always located on the cowl the tank under the cowl makes the adjustment of the wiring and instruments rather difficult. The great advantage is the short feed line and the ease with which any trouble within the feed line is located.

Pressure Feed.—This requires the gas tank to be heavy enough to resist or withstand a light pressure. No vent is provided. On the contrary, the tank must be sealed air tight to prevent the air pumped into it escaping. A pump operated by the engine when it is running is provided to keep the pressure in the supply tank up to a point where the gasoline flows to the carburetor as it is used. A hand pump is used to provide initial pressure in starting after the car has stood a time, or if for any reason the gasoline level falls too

low in the carburetor. This would be the case if the tank was not sealed properly, if the automatic pump failed, or the carburetor was drained. Since the tank in the pressure feed is carried in the rear, one serious disadvantage has always been the number of long air lines and gasoline feed lines to keep in repair. The two pumps are also likely to give trouble and the tank is hard to keep tightly sealed.

Vacuum Systems.—This system is used almost altogether for

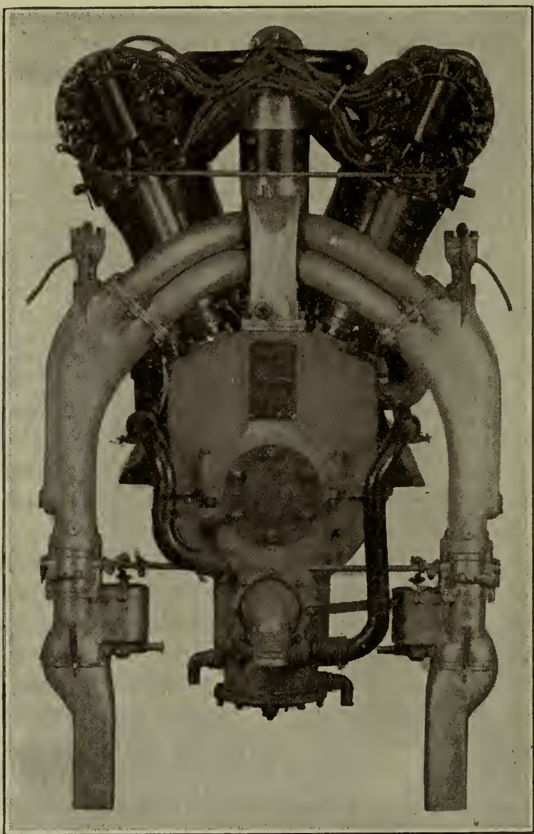


Fig. 230. Packard Liberty Aeroplane Motor Equipped with Fuelizer.

passenger car work and in a large number of commercial cars. The supply tank is placed on the rear end of the chassis, while the vacuum tank is placed under the hood on the dash or on the engine. Gasoline is fed by gravity from the vacuum tank to the carburetor. It is drawn from the supply tank to the vacuum tank. The supply tank is carried on the rear of the chassis and must be lower than the vacuum tank. This system utilizes the best features of each of the other systems. One disadvantage is the number of air and gas lines to be kept free and in service.

Vacuum Tank.—The vacuum tank is so designed as to automatically lift the gasoline from the supply tank to the vacuum tank. A small supply, about half a gallon, is carried in the vacuum tank, from which, as stated, it is fed to the carburetor as needed.

For the student to grasp the action of the vacuum tank it is

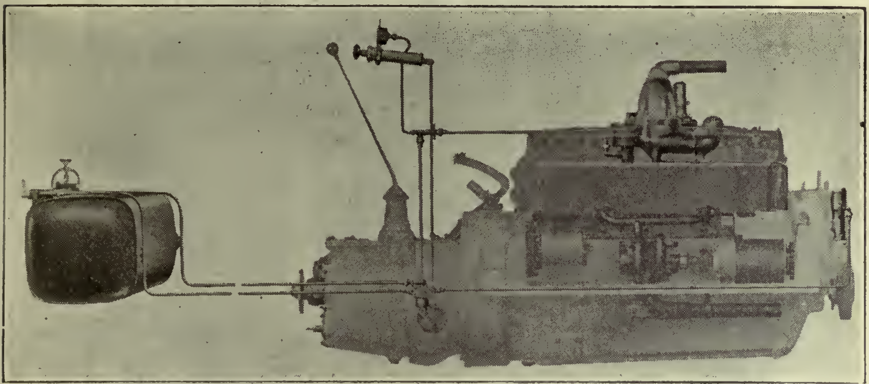


Fig. 231. Packard Twin Six Pressure Feed Gasoline System.

necessary that he understand the vacuum principle. It is commonly said that nature abhors a vacuum. That is, nature seems to make provision that if one element is withdrawn or removed from a certain space or place another element is always on hand ready to move into the place vacated. This may be observed in relation to water. Suppose a brick is placed in a pail and covered with water. Removing the brick does not leave a hole in the water, rather the space occupied by the brick is filled immediately by the water. However, if the water did not fill the space and no air were permitted to enter to fill the place a vacuum would be the result. Again, a dipper may be used to remove part of the water from the pail. Neither does this cause a vacuum as air immediately rushes in to fill the space formerly filled by the water. Having these things in mind, it will be easier to grasp the action of the vacuum tank which is dependent on a natural law for its unfailing response under all conditions.

The upper part of the vacuum tank is connected with the intake manifold of the engine as may be seen in the cut showing the Reo gasoline system, Fig. 232. As the piston travels down in the cylinder on the intake stroke, a suction is created which draws air out of the upper chamber of the tank. Since the air from the outside cannot enter the vacuum tank due to the air valve being held closed, a vacuum is formed or a place in which there is neither air or gasoline. No air can enter the tank except through the main supply tank and here all the gasoline must be forced out of the way. In attempting to

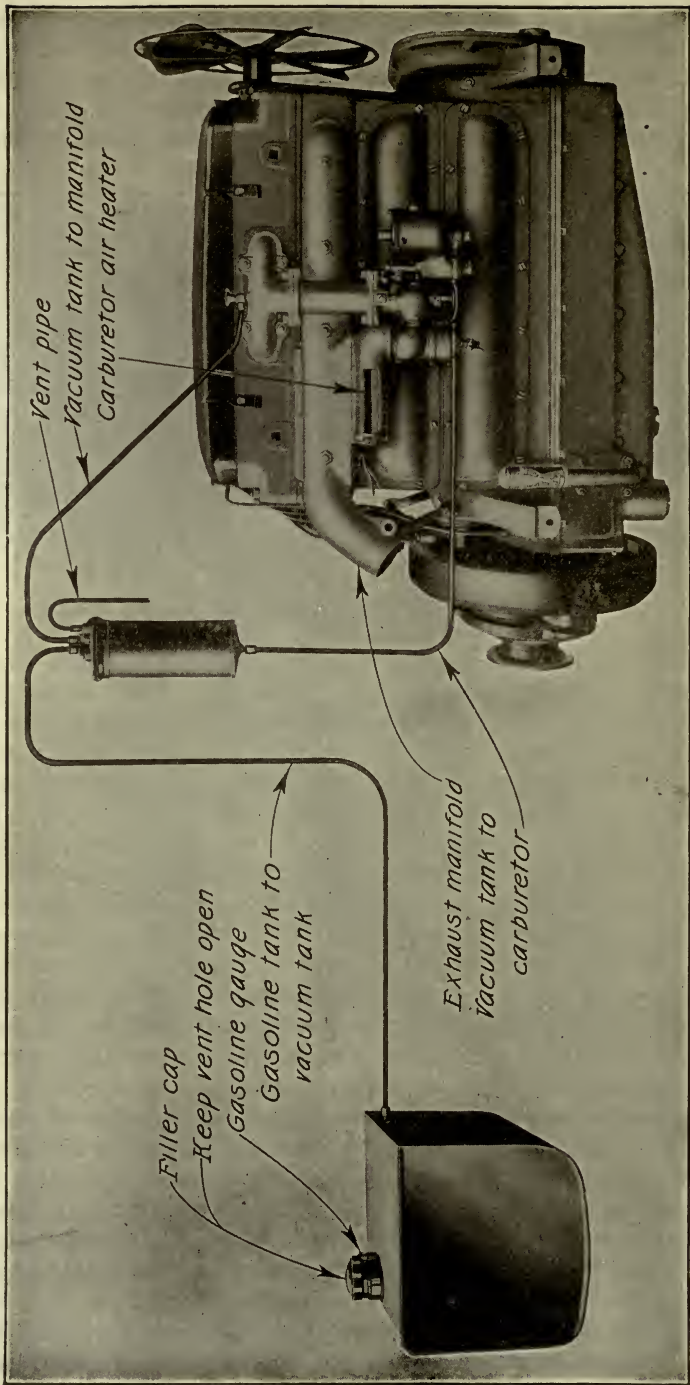


Fig. 232. Reo Vacuum Tank Gasoline System.

enter the vacuum tank through the gasoline supply tank the gasoline is carried ahead of the air. If no more gasoline is placed in the supply tank the air will eventually succeed in getting to the vacuum tank, but only after the gasoline has all been forced up to the vacuum tank, or after the gasoline is all used. As the gasoline is carried into the vacuum tank it first fills the upper chamber and then flows into the lower chamber. When both chambers have the proper level of gasoline in them the float rises to cut off the suction from the cylinder. At the same time the air valve or vent to the upper tank is opened which action permits the gasoline to feed to the lower tank. This lower chamber is always vented through the curved vent pipe. This arrangement insures a supply of gasoline to the carburetor while the upper tank is filling. However, as the gasoline flows from the upper chamber to the lower chamber, the float falls with the gasoline level. At a predetermined point the spring together with the float action causes the air valve on the upper tank to close and the suction valve to be reopened, thus permitting more gasoline to flow into the upper chamber. The above operations are continually being repeated. While the engine is running and gasoline is being used, the operations occur at rather regular intervals, the action being automatically controlled by the rise and fall of the float within the upper chamber. The Stewart vacuum tank is illustrated. All vacuum tanks work on the same principle.

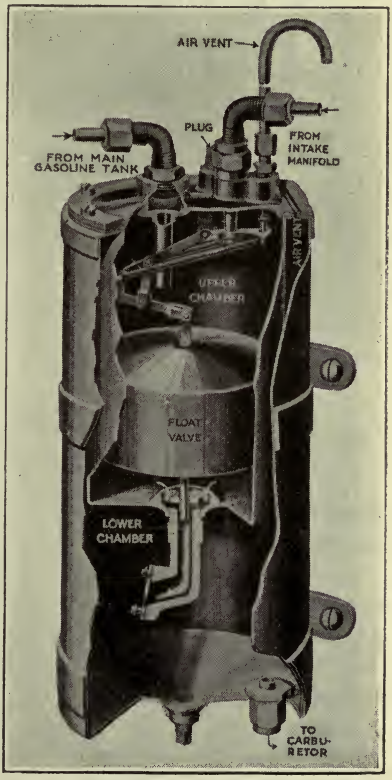


Fig. 233. Stewart Vacuum Tank in Section.

Stewart Vacuum Tank Parts.—Figs. 233, 234 and 235 illustrate the Stewart vacuum tank in section and in detail. A careful study of the illustrations and the text will give the student or mechanic a clear idea of the manner in which it operates.

A is the suction valve for opening and closing the connection to the manifold, and through which a vacuum is extended from the engine manifold to the gasoline tank.

B is the atmospheric valve and permits or prevents an atmos-

pheric condition in the upper chamber. When the suction valve A is open and the suction is drawing gasoline from the main reservoir, the valve B is closed. When valve A is closed then valve B must be open as an atmospheric condition must be present in the upper tank to allow gasoline to flow through the flapper valve into the lower chamber.

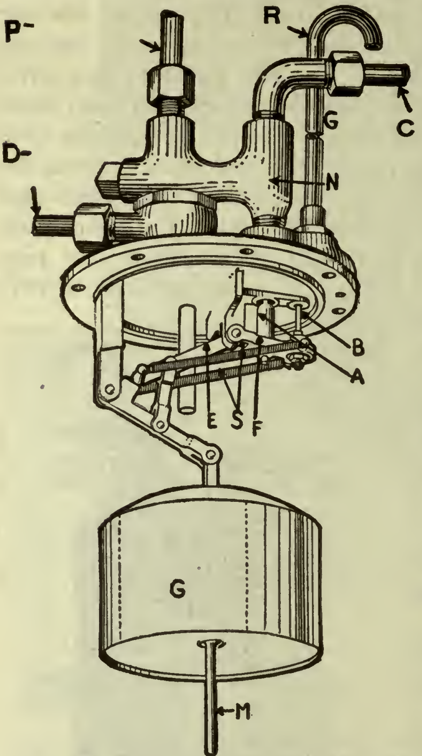


Fig. 234. Float and valve mechanism of Stewart Vacuum Tank.

C is the pipe connecting the tank to the manifold of the engine.

D is the pipe connecting the vacuum tank to the main gasoline supply tank.

E is the lever to which the two coil springs are attached. This lever is operated by the movement of the float G.

F is the short lever which is operated by the lever E, and which in turn operates the valves A and B.

G is the float which operates the valve mechanism as it rises and falls with the gasoline level.

This flapper valve is held closed by the action of the suction whenever valve A is open. However, it is forced open by the weight of the gasoline when the float valve has closed valve A and opened valve B.

A petcock for drawing water or sediment out of the reservoir is provided. It may also be used for drawing off a small quantity of gasoline for priming the engine or for other uses.

A line to the carburetor is extended on the inside of the tank to form a pocket for trapping water and sediment.

A channel space is provided between the inner and outer shells which connects with the air vent, thus admitting an atmospheric condition in the lower chamber at all times. This is necessary to permit of an even flow of fuel to the carburetor at all times.

M is the guide for the float.

N is the vacuum check valve.

P is a pipe line leading to the vacuum pump on the dash. This is not always provided. It is very useful for priming the vacuum tank should it for any reason become empty. It is not necessary to

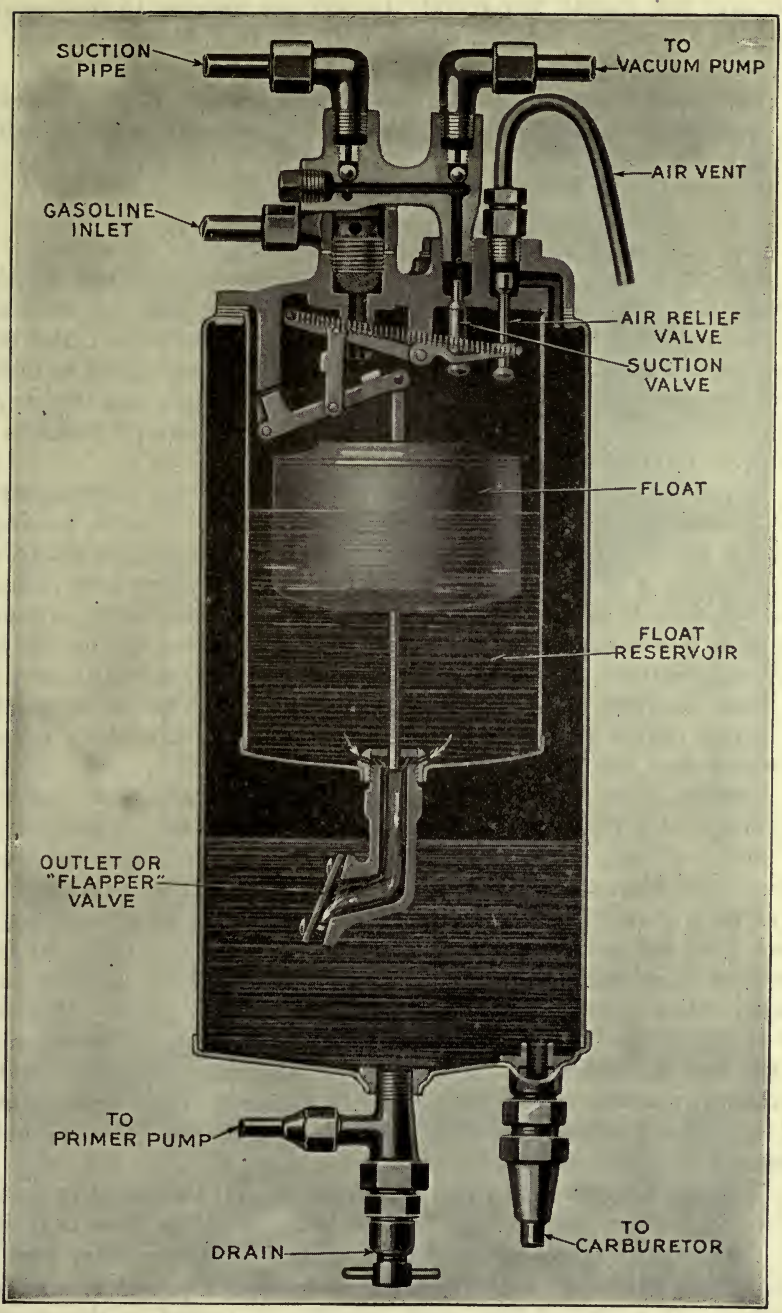


Fig. 235. Stewart Vacuum Tank Operation.

turn over the engine, but merely to pull the plunger in the vacuum pump two or three strokes which will create sufficient vacuum or suction to draw gasoline from the main supply tank.

R is an air vent over the atmospheric valve. It also provides the opening to permit air entering the lower chamber as described on page 218.

PRINCIPLES OF CARBURETION

The act of charging air with a supply of fuel (gasoline) is called carbureting or carburetion. The instrument provided for maintaining the proper mixture at all engine speeds is called a carburetor. The student must understand the principles of vaporization to understand carburetion, as it is only when the fuel is vaporized that it can be mixed with or incorporated in the air as a fuel charge which is an explosive mixture.

Evaporating Liquids.—A great many liquids may be evaporated and caused to float in the air. Water vapor may be seen leaving a river or lake on cold mornings. Fog is water vapor visible to the eye. Steam is a water vapor visible to the eye when first released into the air. It is visible for only a short time, however, although it still remains suspended. Setting a pan of water in the air will cause evaporation to start immediately which process continues until all water is gone or evaporated from the pan. The vapor coming off is not visible to the eye, but does continue steadily, as regular measurements will show.

Clothes hung on the line dry rapidly because the water is evaporated quickly when large surfaces are exposed to the air. If the sun is shining the heat from it will greatly assist in drying them. The evaporating process is always hastened by heat. On the other hand, the sun may not be shining but the wind blowing, in which case the action is again hastened. Clothes dry faster in summer than in winter due to the greater amount of heat, likewise more quickly when more air is brought in contact with them. However, the clothes may be frozen stiff almost immediately on being hung on the line in the winter. This does not prevent them from drying, however, as evaporation still continues although very much slower. All of these observations will help the student to gain an understanding of carburetion.

Volatile Liquids.—If a pan of lubricating oil be placed in a room the smell or odor from it may be detected only when close to it, if at all. If a pan of kerosene is placed alongside of the other pan the fumes from the latter may be detected more easily and at a greater distance. If a pan of low grade gasoline is placed in the room it will be detected by the odor of the fumes at a still greater distance,

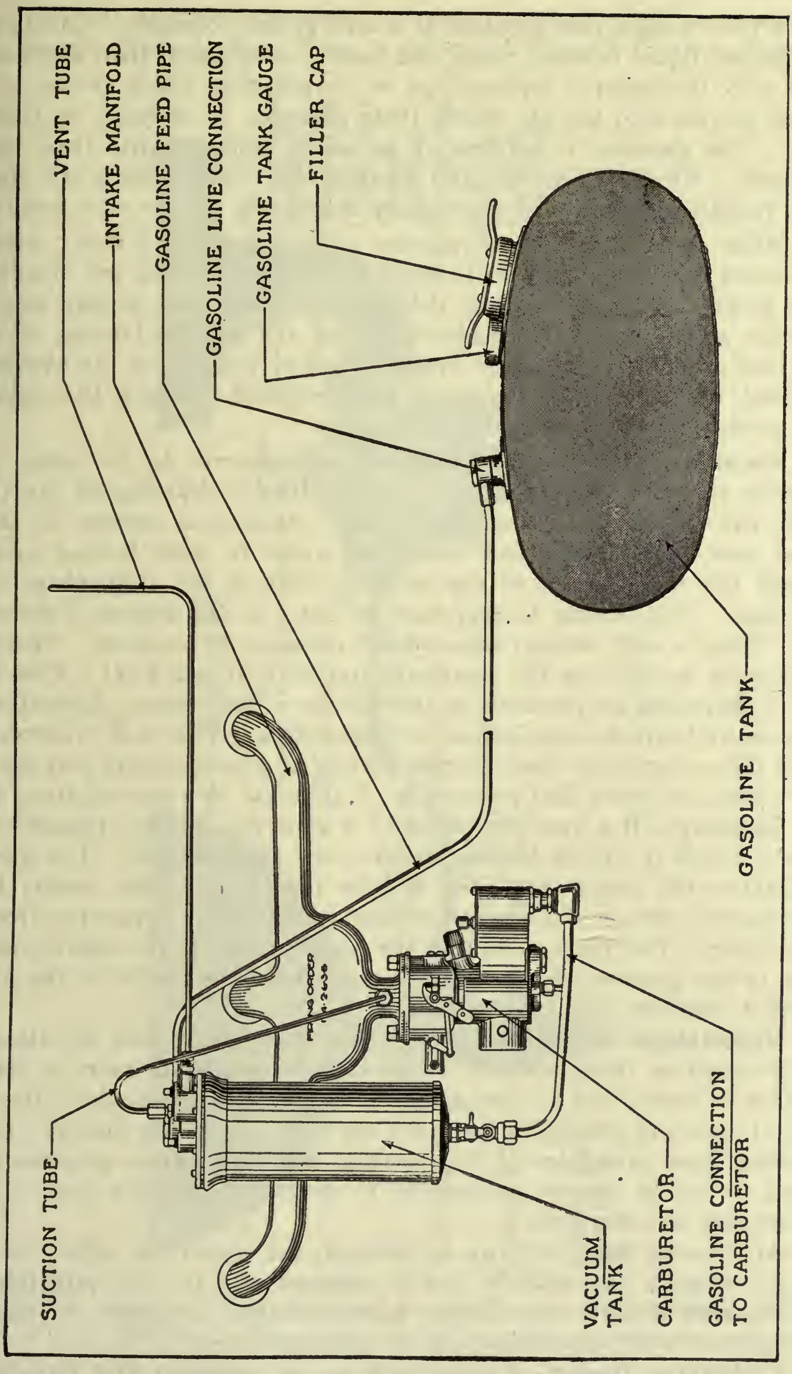


Fig. 236. Buick Gasoline System.

and a pan of high test gasoline at a still greater distance. In other words, one liquid is more easily and readily evaporated than another. It is only the natural vaporization or evaporation which causes the fumes to rise into the air where their presence is detected by their odor. The gasoline is spoken of as being more volatile than the kerosene. Alcohol, benzine, and certain other liquid fuels are also very volatile meaning that they easily float away on the atmosphere.

Heat.—If it is desired to vaporize large quantities of water within a short space of time, heat is applied to it until it boils and steams. The greater the heat applied, the faster it boils and steams away into the atmosphere. The same is true of the volatile liquids, or in this case of the volatile liquid fuels. The less volatile, or the heavier the fuel, the greater the degree of heat required. Hence, the terms low grade and high test fuels.

Vacuum.—A common laboratory experiment is to place a quantity of water in a glass flask. Exhausting or drawing off the air from over the water, or in other words, creating a vacuum in the upper part of the flask will cause the water to start boiling even though the temperature of the water is that of the atmosphere of the room. The boiling temperature of water is 212 degrees Fahrenheit. This is with normal atmospheric pressure at sea level. Water boils more quickly on the mountain top than at sea level. This is due to decreased air pressure on the surface of the water. Reduction of pressure hastens vaporization or evaporation. This was evidenced when the water in the flask started boiling at a temperature less than 100° ; but it requires that practically all pressure be removed from it.

Spraying.—If a quantity of liquid is sprayed into the atmosphere from a nozzle it will be broken up into very fine particles. The finer or smaller the nozzle the finer will be the spray. This results in atomization, that is, the small particles of liquid are separated from each other. The more complete the atomization is, the more complete is the process of vaporization, and the more highly is the air charged with the liquid.

Vaporization and Carburetion.—The student has had his attention focused on these matters with which he is already more or less familiar in order that he may understand the manner in which these natural laws and principles are made use of in carburetor design. By utilizing these principles of vaporization and evaporation gasoline is added to air in proper proportion to give an explosive fuel, and carburetion is completed.

Air bearing **heat** is drawn up through the carburetor where, in a partial **vacuum,** the **volatile** fuel is **sprayed** into it. All **principles** and **features** of carburetor design harmonize and cooperate to make vaporization and carburetion almost instantaneous.

Carburetor Design.—Carburetors are so designed and built as

to make use of all the features, principles, and natural laws enumerated and explained above. Air is drawn in through a stove where it

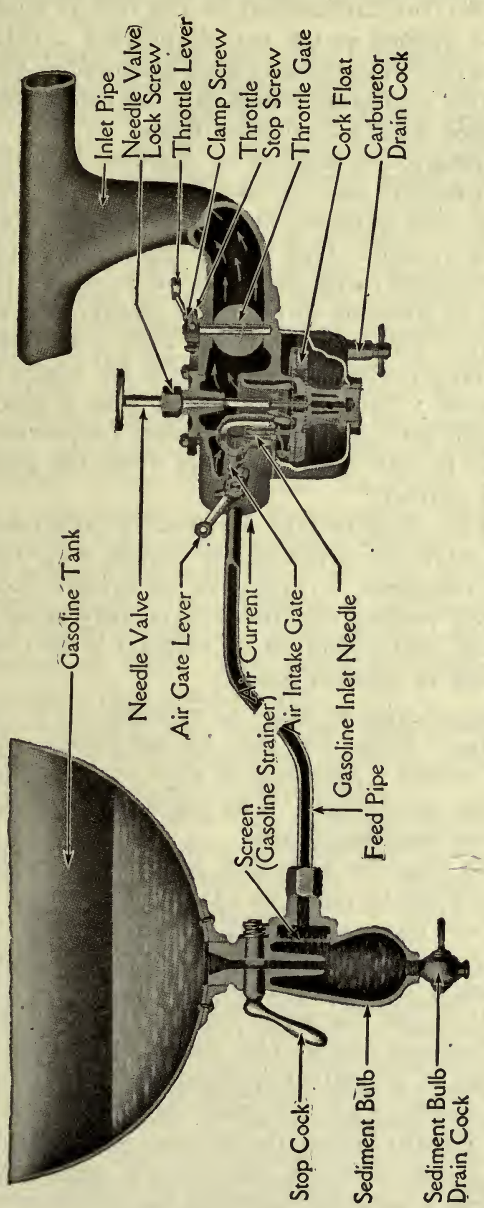


Fig. 237. Ford Gasoline System.

is heated. Next it is drawn into a venturi tube arrangement called the mixing chamber. Here, due to its velocity, it creates a vacuum which in turn draws or sucks gasoline from the spray nozzle. As

this gasoline leaves the nozzle it is atomized. Vaporization is completed by the vacuum and heat. When the proportions of air and gasoline are correct the carburetion of the fuel is completed. Carburetion might be defined as the act of spraying a volatile fuel into the heated air of a partial vacuum in such proportions that the vaporization effected gives a mixture which may be compressed within the engine and exploded with a clean blue flame.

Explosive Mixture.—A mixture of gasoline and air is explosive only in certain proportions. In speaking of and considering the proportions of air and gasoline they are considered with reference to weight and not volume. One part of gasoline mixed with ten or more parts of air is barely explosive. It burns with a reddish yellow flame. One part of gasoline mixed with twenty parts of air again is barely explosive. This mixture burns with a whitish flame. One part of gasoline mixed with fifteen parts of air might be said to be the best proportions. This mixture burns with a clean blue flame. With the very high test gasoline the correct proportion may run as high as seventeen to one while with the very low grade as low as thirteen to one is correct.

In order that the student may understand carburetor adjustment care and repair, there are given below certain conditions which he must be able to recognize. These will be evident from the action of the engine under varying conditions, especially those having to do with speed, power, and condition of exhaust with reference to its sound and the color of exhaust gases.

Rich Mixture.—A rich mixture is indicated by a sluggish motor uneven in operation. It has less than normal power. Exhaust gases may show black smoke. Response is slow on opening the throttle. Over-fed conditions are evident. The engine does not choke quickly, but will die a slow lingering death.

The condition may be remedied by adding to the air supply or permitting more air to enter by making proper air valve adjustments. It may also be remedied by cutting down on the gasoline allowance. Either action will result in leaning the mixture.

Lean Mixture.—A starved condition is evident here. If the engine runs at all, it will run faster than the over-fed motor. Again, it has less than normal power. Its surest indication is popping at the carburetor due to premature ignition, commonly called pre-ignition. With this condition present black smoke never will be noticed at the exhaust. Usually, when the mixture is leaned out too much, the engine will speed up for a few seconds and then come to an abrupt stop. With a very rich mixture the engine may continue to chug along for quite a time.

This condition is remedied by enriching the mixture. To do this, close off some of the air supply by adjusting the air valve spring.

Or, the same result may be arrived at by opening up the gasoline needle until enough gasoline is added to the air to give the proper proportion for the mixture.

Correct Mixture.—When the correct mixture is reached from either of the two extremes explained above, it will be evidenced by a smooth running engine and a return to normal power. In the case of a return to normal power from an over-rich mixture some little time will be needed to drive out the logged gases and burn the spark plugs clean of soot and smoke, which is bound to be left in the cylinder and on plugs by an over-rich mixture. The proper mixture would be evidenced by a clear blue flame if it could be seen. If the student is familiar with the gasoline stove or torch he will recognize this flame immediately. As the student has doubtless noticed, an imperfect mixture in the use of a gas or gasoline stove usually burns yellow and smokes. This is the condition in the rich mixture in the engine where the smoke and soot are deposited as carbon.

Power.—The motorist says he has great power, has no power, or has just average power and speed. As a rule this means good, bad, or average combustion of the gases within the cylinders, which is the real source of all power developed in the car. Other conditions may be present which cause mechanical troubles, or poor ignition, but the most frequent cause of loss of power is poor carburetion.

A properly mixed charge of fuel explodes with great heat and tremendous expanding force. This forces the piston down into the cylinder with decided force and power.

A mixture containing too much fuel burns slowly rather than exploding. The gases form slowly and push the piston down as they form. Their expanding power is vastly less.

The mixture which is too lean explodes quickly. The volume of gases formed by the explosion is insufficient to fill the entire combustion chamber with high pressure gases. It might be characterized by comparing it with an attempt to drive a heavy nail with a tack hammer. Not enough energy can be developed.

Venturi Tube.—Practically every type of carburetor utilizes the principle of the venturi tube to hasten vaporization of the gasoline. This tube comprises an important part of the mixing chamber. The venturi may be detected in any of the carburetor illustrations as that part having a contracted neck or portion with the spray nozzle ending in the throat. The velocity of the air passing through the throat or neck is increased. After it is through and there is more room, the air expands thus forming a partial vacuum. The gasoline is sprayed into this neck. This action might be likened to a column of soldiers marching through a narrow portion of the roadway. After passing through the narrow portion they maintain the same speed but spread out to occupy a greater space on the road. In other words, they are

farther separated. In the case of the air, the same quantity fills a larger space, but the particles are farther apart, or a partial vacuum has been caused.

Nozzles.—Many types of nozzles are used, some fixed and some adjustable. In the case of the fixed nozzle the auxiliary air valve is adjustable. Where no auxiliary air valve is provided the nozzle is always adjustable. Where the nozzle is made adjustable it is done by providing a needle valve within it. By controlling the size of the opening, the amount of gasoline permitted to flow under any and all conditions may be regulated.

Gasoline Level.—This is maintained at all times just below the top of the nozzle in the venturi tube. Whenever, for any reason, the level comes higher, the carburetor is said to flood. About ⅛″ is correct. If too low, that is more than 3/16″, great difficulty will be experienced in starting the engine. It is also liable to give trouble when operating at low speeds due to the fact that the suction within the venturi is insufficient to lift the gasoline from such a low point.

Float and Needle Valve.—A float, either hollow metal or cork, is provided to maintain the gasoline at the proper level. The operation is automatic. The gasoline enters the bowl from the feed line, the float rises on the gasoline until at a predetermined point the needle valve is forced down on its seat thus shutting off the flow of any more gasoline until some has been used out, at which time the float again falls permitting gasoline to flow until the proper level is again reached. The action of the float and the needle valve is continuous while the motor is in use. In time the valve and valve seat will become worn to such an extent by this continuous action that it will be found necessary to replace them or reseat them in order to prevent the gasoline leaking through.

Float Troubles.—A common fault of either type of float is logging. By this is meant that gasoline has found its way into the float and has made it heavy. In the case of the cork float the shellac is penetrated and the porous part of the float is filled. In the case of the hollow float it develops a small leak from which air escapes and through which gasoline enters the float. Dirt may lodge under the needle valve and thus fail to control the flow from the feed line, but if the float sinks to the bottom of the carburetor bowl and fails to give a lively response when submerged the indications are those of a logged float. If the float responds as it should but gasoline continues to flow, the trouble is with the needle valve. This dirt may often be washed out of the valve by holding the float down, thus allowing the gasoline to wash out the valve as it rushes in. The carburetor should be drained occasionally to remove any sediment which has collected in the bowl. This also removes the water which has collected at the bottom of the bowl.

Hot Air Stove.—Heat is added to the air as it passes on its way to the carburetor. The hottest exposed part of the engine is the exhaust manifold. On this or on the exhaust pipe the designer fits a sheet metal cover having air passages arranged in such a manner that the air going to the carburetor is drawn in and around the exhaust pipe, and after being thus heated passes through the flexible metal tube to the carburetor. Stoves are cast integral with the manifold in some cases.

Hot Spot Manifold.—With the use of lower and still lower grades of gasoline it has been found necessary to increase the amount of heat provided to the incoming charge. This is due to the fuel being less volatile as explained previously. It insures better combustion and economy of operation. The incoming charges pass along a wall heated by the outgoing exhaust gases. The heat from the one chamber is transferred through the wall to the gases in the other. A variety of forms of manifolds are in use but the principle is the same; that is, heat is added to insure vaporization. The manifolds are cast together. In some cases pins are cast on either side of the separating wall so that the exhaust gases heat these pins and the incoming charge cools them and is in turn heated. The plan is being adopted rather generally.

Hot Water Heat.—Carburetors and intake manifolds are sometimes water jacketed to increase the amount of heat available to the incoming fuel charge. The greatest fault with this system is the slowness. The car will travel from several miles upward before the proper temperature is secured to stop spitting of the carburetor and to insure economic operation. The great fault of all carbureting systems is that the raw gasoline drawn in, in warming up the gasoline, finds its way down past the pistons into the crank case there to work all manner of harm. The water heat is clean and will insure a smooth running motor when the proper temperature is reached. This is about 170 degrees. Another method of utilizing the heat from the water to do this work is to cast the intake manifold integral with the cylinder head. The water in this case is circulated around the manifold. This construction is not apparent to the casual observer. Manifolds cast in heads which are not cooled as thoroughly as was the former practice are also in use. Here the direct heat from the gases burning in the cylinders is used to heat the incoming fuel.

Exhaust Gas Jackets.—These are used in remedying carbureting systems of the older cars. A jacket is provided around the intake manifold. The ingoing charge passing through the manifold absorbs the heat through the intake manifold wall which is heated by the exhaust gases flowing through the jacket. Only part of the exhaust from the engine is conducted through the jacket. The repairman can often fit up a car of an older type with this system to good

advantage. Each case has to be handled individually but results are assured. Some carburetors are provided with jackets through which part of the exhaust gases are shunted to heat the gasoline in the bowl. The greatest difficulty encountered here is to keep the jacket free of carbon deposits.

Choke Valves.—When starting a cold engine, no heat being available, the vacuum principle plus the atomizing effect of spraying the charge from the nozzle must be depended on entirely for vaporization. To increase the vacuum the air intake line has a butterfly valve placed in it which may be closed to choke off the air supply, thus causing a richer charge of gasoline to be drawn into the mixing chamber where the increased vacuum helps vaporization. From this greater supply of gasoline, or richer charge, enough gasoline will be vaporized to get the initial explosion and to start the motor running. Immediately the engine has started to run under its own power, it is necessary to release the choke valve to admit more air, or the engine will be choked by the over-supply of gasoline. Too much gasoline in the engine cylinders or the combustion chamber is spoken of as flooding the engine. On stopping the engine many drivers partially or wholly choke the engine to insure ready starting. This is a good practice for extremely cold weather. In warm weather a flooded motor may be the result.

The spring provided to hold the choke valve open should be inspected occasionally to insure its being maintained in proper condition. It should be held wide open at all times, excepting only when its use is desired. If it becomes loose and swings about, the engine is certain to run unevenly.

Air Valves.—In order to maintain the proper mixture of air and gasoline that is 15 to 1 by weight at all speeds, it has been found necessary to equip the carburetor with some device which will automatically maintain these proportions after the spray nozzle has been adjusted properly. This is handled differently by the various carburetor designers. One method long popular requires that an auxiliary air valve be placed in the carburetor in such manner that it may be acted on as the inrush of air or suction becomes greater at the higher engine speeds. This auxiliary air valve is shown in a number of the illustrations of carburetor sections. Its position should be studied carefully. It serves the one purpose of maintaining the proportion of air and gas no matter what its design, location, or method of control may be.

Were it not for this air valve the fuel charge would become too rich, thus causing the motor to operate unevenly. The most common type of air valve is the one whose action is controlled by a coil spring. The tension on this spring is adjustable through a thumb nut arrangement which increases or decreases the tension on the spring. This

adjustable feature is necessary to insure the action of the valve at just the position required to prevent the mixture becoming too rich. The springs used are very sensitive and are especially wound for this work. If, for any reason, the spring becomes damaged, it is best to replace it with a new one. A repaired spring is likely to give an uneven jerky action to the valve thus causing the motor to run very unevenly. Neither may these springs be secured at random, but the spring furnished by the carburetor manufacturer should be used. The straight coil spring is not used very largely for this work. Either two springs of varying tension are used, or a spiral wound spring is furnished.

Adjusting Air Valve.—If there is a low speed adjustment, it should be set to obtain the best idling speed for the engine while the air valve has enough tension on it to insure its remaining closed. When the proper setting for the slow speed nozzle has been secured the mechanic may proceed to adjust the air valve. First turn the thumb nut until the tension is greater than needed. Open the throttle quickly. The engine will give forth the usual indications of too rich a mixture, will be found to be sluggish, and black smoke may possibly be seen coming from the exhaust.

Next release the tension on the spring, testing each little turn of the thumb nut as suggested above. Continue the operation until a point is finally arrived at, at which the carburetor pops when the throttle is quickly opened. Next increase the tension on the spring until, when the throttle is opened instantly, the engine picks up at its best speed without pause or backfire. With the setting at this point the car should be tested for speed and power. A little variation may be necessary as indicated by lack of power or sluggishness.

Air valves are not always controlled by spring tension. In some cases they are made to operate by gravity in which case they are not readily adjustable. The suction of air draws the valve from its seat allowing the proper amount of auxiliary air to enter to maintain the mixture in proper proportions, 15 to 1, for all speeds. As speed and suction decrease, the air valve drops back on its seat forced down by its own weight. Since the air valve cannot be adjusted, all adjustments must be made on the gasoline nozzle.

Adjusting Gasoline Nozzle.—This operation is performed in much the same manner as the adjusting of air valves. The results arrived at are the same. A proper mixture is secured. The mixture should be made too rich by opening the nozzle to a point where, when the throttle is opened suddenly, the engine is sluggish and fails to respond in a lively manner. Other signs of a too rich mixture are present. Next close the adjustment a trifle making the test of opening the throttle. Continue this until the best running point is arrived at and passed. When the lean point is noticed by the popping at the car-

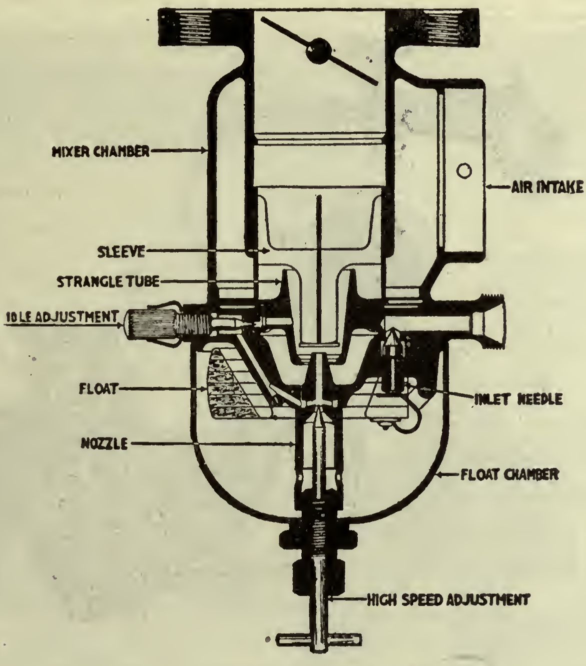
buretor, the adjustment must quickly be enriched or the motor will stop. Continue increasing the supply of gasoline until again the motor operates at its best speed without popping and without pause when the throttle is opened instantly. Test the car on the road as before and adjust finally as need is shown. These instructions are given to acquaint the student with the principle of carburetor adjustment as applied to simple carburetors. Under the description of special makes of carburetors will be found directions for adjustment of same.

Throttle.—The throttle is a butterfly valve located in the top of the mixing chamber of the carburetor. Opening the throttle means opening this valve until, at a wide open position, the valve stands in each case in a position to allow the maximum amount of air to flow past it. Closed throttle means that the valve rests almost straight across the top of the mixing chamber. A very small opening is left for the passage of air on a closed throttle. In a closed position the engine is said to run at an idling speed meaning it is carrying no load. Closing the throttle does not stop the engine as in the case of a steam engine, but permits it to continue at the idling speed until the spark is turned off. In some models of carburetors a gasoline nozzle is introduced at the point of closing of the throttle to provide a spray of gasoline for slow speeds and starting work. Special devices and attachments are at times used by designers in conjunction with the butterfly valve to provide the throttling mechanism.

Metering Pin.—This device is used to control the amount of gasoline entering the mixing chamber. It may be used either as the principal adjustment or merely as an auxiliary feature. It consists of a long metallic pin fitted into a nozzle in such a manner that it carefully measures or meters the amount of gasoline permitted to flow by it at various speeds and settings. In some cases it is actuated with the throttle in fixed relation to the opening and closing of the same. In other cases it operates in conjunction with air valve dash pots. The metering pin in its relation to individual design is brought out in the illustrations.

Dash Pot.—The dash pot is a separate gasoline chamber, or bowl, in which the gasoline level is maintained at the same level as that of the carburetor bowl. This is done by the float and needle valve arrangement which controls the level in the bowl. A passageway connects the bowl and pot. When the auxiliary air valve is drawn down the dasher within the pot forces up a quantity of gasoline which is sprayed into the auxiliary air to insure acceleration. The dasher, which is connected to the air valve, tends to hold same steady and prevent fluttering. The student will study the action of the metering pin in the designs utilizing it as described and illustrated in the succeeding pages.

Plain Tube or Compound Nozzle Type.—Here is found perhaps the simplest carburetor in point of moving mechanical parts. Natural laws and principles are substituted for mechanical devices. The student was shown how the low speed mixture grew too rich when the throttle was opened and the suction increased. To compensate for this an additional feature is provided so arranged that the fuel charge is always too weak or lean. The two combine to maintain at all speeds the proper mixture. The regulation of the amount of gasoline



Carbureror Assembly

Fig. 238. Maxwell Carburetor in Section.

to the amount of air is held at 15 to 1 automatically. Adjustments for high or low speeds may or may not be provided in carburetors using this principle, which is called the Baverly principle after its discoverer.

Air-Bled Jets.—In the air-bled jets a small quantity of air is admitted through and with the gasoline. This tends to break up the gasoline and make atomization more complete as it is sprayed from the nozzle into the mixing chamber.

JOB 84. MAXWELL CARBURETOR.

Several styles of carburetors have been used on the Maxwell 25. The photographic reproduction shown in Fig. 239 is the earlier type. The gasoline adjustment is shown as the needle valve. This valve is controlled from the

instrument panel within certain limits. If the carburetor has been dismantled and is being reset, the needle valve should first be turned all the way to its seat. Next it should be opened to about three-fourths of a turn, after which the needle valve handle binder screw should be locked. This should be with the dash control on center. Throwing this handle to the one side, closes the needle valve giving a leaner mixture. Throwing it to the other side gives a richer mixture because the valve is opened. The lean position should be in use for driving on the level, while the neutral or rich position will have to be used for hard going. This is the only adjustment on the carburetor. The auxiliary air valve is a hollow brass ball which is raised from its seat by the

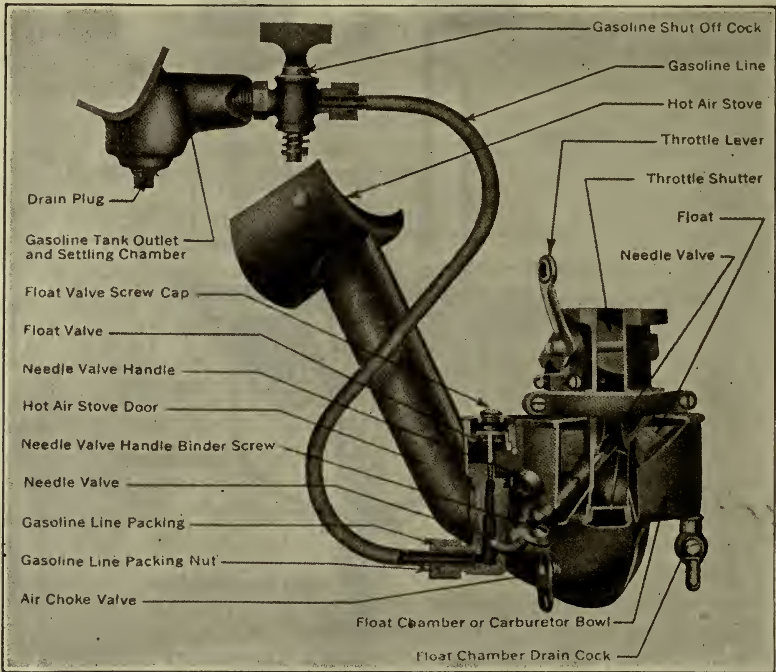


Fig. 239. Maxwell Carburetor and Fittings.

increased suction to admit additional air. This ball may be seen in the center of the cut.

MAXWELL 25—1919. A section of the 1919 carburetor is shown in Fig. 238. This is provided with two adjustments. Proceed as follows to adjust this carburetor. With the engine idle turn both idle screw and high speed screw to their seats. Set the throttle lever stop screw to the approximate idling position. Next open the high speed needle one and one-half turns. With these adjustments made the engine should be started and run until it is as warm as actual service conditions would make it. Next place the spark control in a retarded position and open the throttle until a driving speed of twenty to twenty-five miles is reached. Next turn the high speed needle to the right or close it until the engine tends to stop from too lean a mixture. Turn it open or to the left until the engine shows signs of too rich a mixture. The engine will roll and show signs of slowing, choking, and stopping. Next turn the needle to the right again and at a point about midway between the two extremes will

be found the point of greatest speed as well as of best mixture. Now the idle adjustment screw should be set. The throttle should be closed at this time. Should the engine fire unevenly, turn the idle screw to the left to enrich the mixture, or to its seat to make the mixture lean or poor. The approximate position for this screw is one-half turn out. The throttle as well as the spark should be fully retarded.

JOB 85. PACKARD TWIN SIX CARBURETOR.

Single Jet. The Packard carburetors are of the single jet or spray nozzle type. This nozzle is located in the center of a mixing chamber or venturi. As

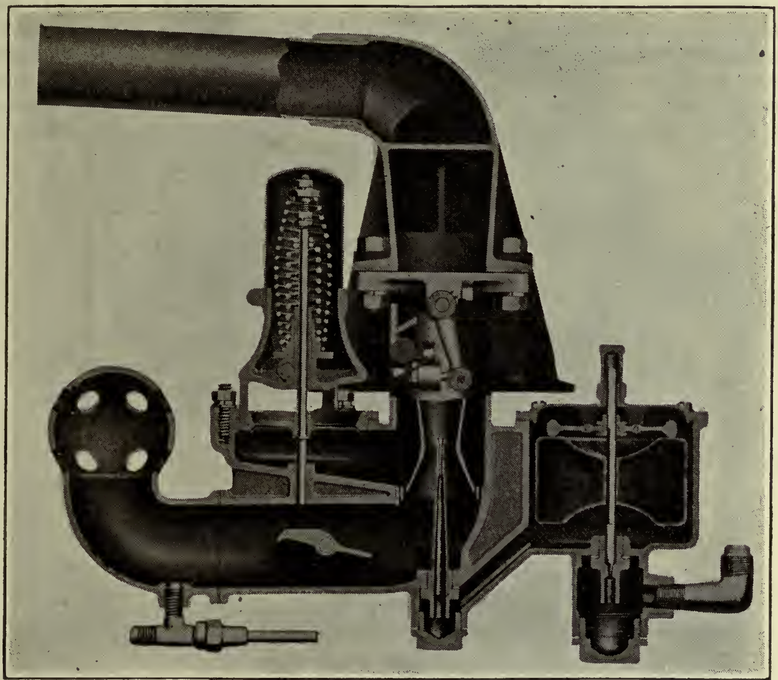


Fig. 240. Packard Car Carburetor.

noted in the illustration, Fig. 240, both the primary air and auxiliary air act on the one nozzle. The primary air comes through the usual type of air passage provided with a choker which is used only for starting or cold weather work. The action of mixing and vaporizing is the same as previously explained for this type of carburetor. Heat is secured from the hot water jackets around the cored intake and from the exhaust manifold. The single jet is not adjustable, but all adjustment is secured from the auxiliary air valve.

Auxiliary Air Valve. The illustration shows this in a housing forward of the mixing chamber. It is controlled by two springs, one within the other. At low or idling speed this valve admits very little air. The air supplied comes through the other passage and up through the mixing chamber, past the nozzle, where it picks up the gasoline. To prevent too rich a mixture, the auxiliary air valve opens with increased suction allowing the needed air. This insures the correct mixture at all speeds, as the greater the suction the greater the

action of the air valve. Changing the spring tension affects the quality of the mixture. Cams placed beneath these springs are controlled from the dash. Pulling the air control button out will increase the tension on the springs thus giving a richer mixture. The proper setting of the button, for ordinary running, is flush with the dash. If, for any reason, these cams are disassembled the greatest care should be exercised to see that they are reassembled in their original position. In warm or hot weather it is possible to so flood the engine by use of the choker that the mixture cannot be fired. This is a trouble experienced frequently by the inexperienced.

Throttle. This is of the butterfly valve type. As in all cases the valve is provided with a set screw which is adjustable for idling speeds. The throttle is so adjusted that there is always room for sufficient mixture to pass to keep the engine running when the control is all the way back. Except for this provision the engine would stop whenever the control or accelerator were returned to either a normal or off position. To increase the minimum speed, loosen the lock nut and turn the screw forward. To decrease the minimum or idling speed, turn the screw backward or out. This should be done with the engine running in order to note the effect on the engine, and that the mechanic may know from the sound of the motor when the best idling speed is reached. Be quite certain to lock the screw with the check nut when the adjustment is completed.

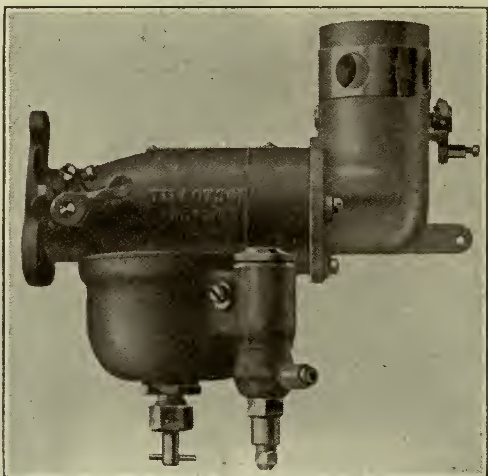


Fig. 241. Tillotson Carburetor.

JOB 86. TILLOTSON CARBURETORS.

Instructions for Adjusting. All models of Tillotson carburetors are equipped with the automatic air valve not adjustable. The gasoline only is adjustable, and that is regulated by adjusting the primary needle valve adjustment on the primary fuel supply nozzle.

To secure the correct adjustment, first warm up the motor. Next, close the throttle so that the engine will run reasonably slow. Then turn the adjustment to the right or up a little at a time until the motor commences to slow down as a result of being starved of fuel, and then turn the needle back to the left about one-eighth of a turn. This should give the correct mixture, and if all other conditions of the motor are normal, the results obtained should be a maximum of power at the best economy of gasoline used.

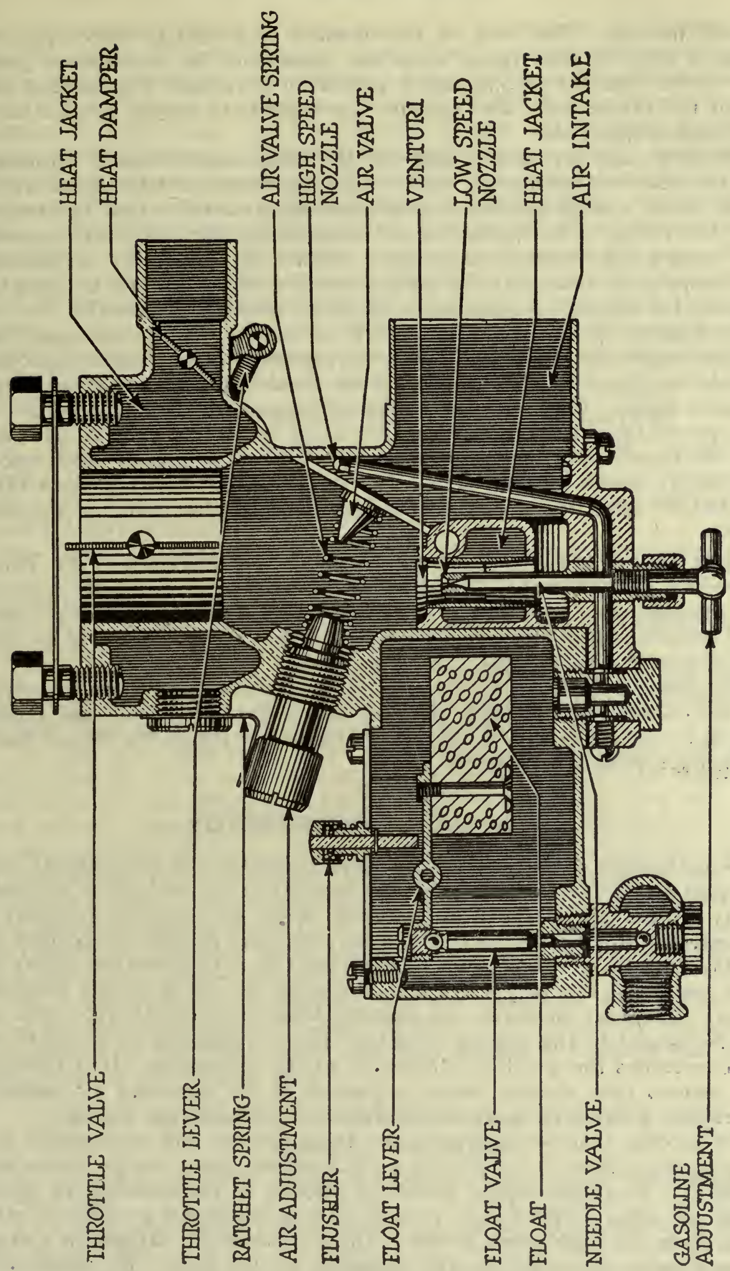


Fig. 242. Buick Carburetor.

Automatic Air Valve.—The design of the air valve provides a small opening through which the air enters when the motor is running at slow speeds. The area of this opening is so designed as to equal the requirements of the motor

at closed throttle. The area of the opening is gradually increased by the yielding of two flat steel reeds which are opened by the atmosphere pressing against them from the outside when suction or a vacuum is produced on the inside of the carburetor. The vacuum corresponds to engine speeds, likewise the opening of the reeds.

The reed cage provides a seat for the reeds which should normally lie flat on the seat thus sealing the valve. The maximum partial vacuum will only open the reeds a small portion of their maximum elasticity thus insuring long life for the reeds. The amount of air required by the motor at any and all speeds being predetermined, the correct mixture is obtained by the placing of the fuel supplying nozzles in the path of the air and supplying an adjustment to regulate the amount of gasoline to be drawn through the nozzles.

The position of the secondary nozzle is such that it supplies gasoline at the higher engine speeds only. Since the primary nozzle supplies gasoline at all speeds an adjustment of it covers both nozzles, or rather the mixture for any engine speed. If the primary nozzle adjustment is made correct for slow engine speeds, then the secondary nozzle, being of correct size and design, will supply the correct amount for the higher speeds. The student will note that the secondary nozzle commences to deliver gasoline at partially open throttle and leaves off again when the throttle has reached a like point in the closing operation.

Warm Air.—Warm air is essential to the proper operation of the Tillotson carburetors. Hot air stoves should always be provided. A screen is provided at the gasoline inlet connection. This will have to be cleaned from time to time to insure the free flow of gasoline to the float bowl. The cold air shutter should be used during periods of extreme heat.

The choker valve should be closed for starting only. When the motor is warm the choker must be wide open to insure greatest power and economy. Attention to choker springs is necessary at times to insure the proper working of the choker valve or strangler.

JOB 87. BUICK CARBURETOR.

The carburetor is the instrument which measures the fuel charges for the motor. and mixes them with the proper amount of air to form a combustible gas. At a high rate of speed the velocity of the air entering increases until the air valve is lifted from its seat and an additional amount of gasoline spray is taken from the high speed nozzle. Since more air is admitted the quality of the mixture going to the motor remains the same as the demands increase or decrease. The float maintains the gasoline level in the usual way. The spray nozzle is located in the mixing chamber, and is regulated by a needle valve which constitutes the gasoline adjustment of the carburetor. It is surrounded by the venturi tube through which a portion of the incoming air passes at a high velocity, picking up gasoline from the end of the spray nozzle.

The mixing chamber also contains the air valve and high speed nozzle. The air valve is held to its seat by an adjustable spring which forms the air adjustment. At a high engine speed the velocity of the entering air increases until the air valve is lifted from its seat and an additional amount of gasoline is taken from the high speed nozzle. The air enters the carburetor through a three-way valve controlled by the regulator on the dash. By means of this arrangement the air may be taken from the heater under the exhaust manifold, or directly from the atmosphere. By means of the choke position the carburetor is made to draw excessively rich charges for starting. The throttle is the usual butterfly valve type.

Exhaust Heater.—The upper end of the mixing chamber and the venturi

tube which houses the slow speed nozzle are surrounded by jackets through which some of the exhaust gases pass. This is the arrangement previously mentioned as assisting in vaporization. A damper valve controlling the amount of exhaust entering the jacket is controlled by the throttle levers, working in conjunction with them. At low throttle speeds the throttle is wide open permitting the greatest possible amount of heat to enter. At high speeds, when the air velocity and vacuum is great and less heat is needed, the damper is closed. This system of exhaust heat to carburetor is controlled by the Season Adjustment Valve or Carburetor Exhaust Heat Jacket Shut-Off Valve. This valve is located on the exhaust heat inlet tube at the end next the motor. In warm weather, or with high test fuels this valve should be closed. This shuts off all exhaust heat from the carburetor, thus preventing loss of power and overheated motor. In cooler weather this valve should again be set open. It is best to keep it open always unless loss of power may be attributed to it. Proper handling of it makes for greater fuel economy.

ADJUSTING BUICK MARVEL CARBURETOR.

1. Turn the gasoline adjustment to the right until the needle valve is closed.
2. Set the air adjusting screw so that the end of the screw is even with the end of the spring above it.
3. Open the gasoline adjustment by giving the screw one full turn.
4. Start the motor as usual, allowing it to run with the regulator on the hot position until the motor is warmed up.
5. With the spark lever fully retarded turn the gasoline adjustment to the right, closing the needle valve until the motor idles evenly.
6. Advance the spark lever and turn the gasoline adjustment to the left until the motor begins to miss or skip, indicating too much air; then turn to the right again until the motor again runs smoothly.

To test the adjustment leave the spark lever advanced and open the throttle quickly. The motor should accelerate instantly. If it skips or pops back, open the gasoline adjustment a little by turning to the left. Do not touch the air adjustment again unless it should appear absolutely necessary. The best possible adjustment has been secured when the gasoline adjustment has been turned as far as possible to the right and the air adjustment as far as possible to the left, letting the motor run smoothly and accelerate quickly when the throttle is suddenly opened. Care should be exercised to keep the exhaust heat tubes and carburetor jacket clean to insure heat circulation, which enables the motor to run better and give greater efficiency.

No attempt should be made to adjust the carburetor until certain that the motor has good compression in each cylinder; that a good hot spark occurs in each cylinder at the proper time; and that gasoline is reaching the carburetor regularly from the vacuum tank.

JOB 88. KINGSTON CARBURETORS MODELS E AND L.

Model L. To Adjust—

1. Retard spark fully. Open the throttle about five or six notches on the steering post.
2. Loosen the needle valve binder nut on the carburetor until the needle valve turns easily.
3. Turn the needle valve in until it seats lightly. Do not force it or the size of the nozzle may be changed. Adjust it away from the seat one and one-half turns. This will be slightly more than necessary, but will assist in easy starting.
4. Start the motor and adjust the throttle position by the quadrant or hand

control until the motor runs at a fair speed. Do not run too fast. Allow the motor to run long enough to warm up to normal service conditions. The final adjustment may now be made. This carburetor has but the one adjustment, that of the needle valve. Close the throttle until the motor runs at the desired idling speed. This can be controlled by adjusting the stop screw on the throttle lever.

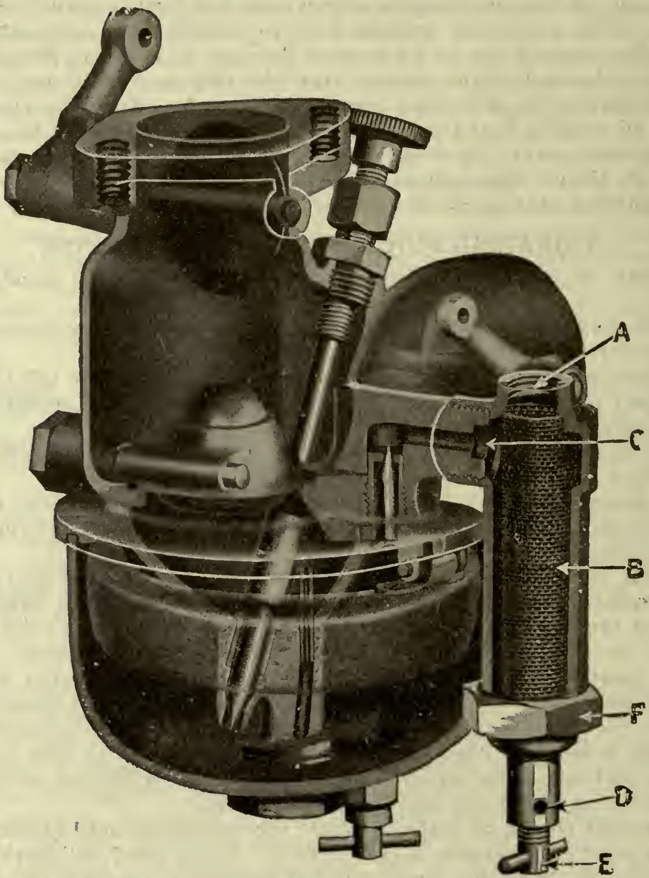


Fig. 243. Kingston Fuel Strainer and Carburetor.

Fuel enters strainer at point A, is strained by the fine gauze wire B, and, cleared of all sediment and impurities, is taken into the carburetor at point C. At the base of the strainer is a pocket to catch water and sediment. By turning the cock E the water can be instantly drained at the small port D. The strainer can be easily cleaned by removing the cap nut F, taking out the strainer and its cage, cleaning it and putting it back in place. This strainer, which will do away with many carburetor troubles, can be attached to any Kingston Model L or Model L2 carburetor.

5. Adjust the needle valve toward its seat slowly until the motor begins to lose speed indicating a weak or lean mixture. Now adjust the needle valve away from its seat slowly until the motor attains its best and most positive speed. This should complete the adjustment. Close the throttle until the motor runs slowly, then open rapidly. The motor should respond strongly without popping or hesitating. Should acceleration seem slightly weak or sluggish the needle should have such slight further adjustment as to remedy

this trouble. When final adjustment is secured lock the adjustment or binder nut.

Care of Carburetor.—The bowl of the carburetor is provided with a drain cock and should be drained frequently to remove sediment and water. Gasoline leaks should receive prompt attention. Flooding is a sure sign that the float valve is held from its seat by dirt or foreign matter of some sort. To remedy this, remove the needle valve cover and by means of a small screw-driver give the needle valve a few turns. The top of the valve is provided with a slot for the use of a screw-driver. The needle valve is held in place in relation to the lever by means of a ball and socket joint. Care should be exercised to see that the joint is not binding.

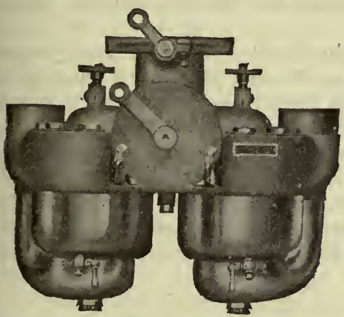


Fig. 244. Kingston Dual Model.

It is always worth while to filter the gasoline being used. Failure to do so will give the mechanic work in cleaning out the carburetor as the dirt finding its way into the carburetor will clog fuel passages and nozzles, causing irregular operation of the engine. Trouble of this nature is rather difficult to find at times. A very frequent cause of trouble is a clogged fuel line.

Model E.

The construction as well as action of this carburetor is apparent from the drawing shown in Fig. 244. Gasoline is admitted at 24 and continues to flow until valve 22 is seated due to the bouyant action of float 5. The attention of the student is particularly called to the shape of the spray nozzle 8 which forms a cup around needle valve 7 above its seat. The gasoline level is 1/32″ below its top. This excess of gasoline is available for starting and furnishes a very rich charge. After the well is emptied it does not refill until the engine is again stopped. The regulation of the amount of gasoline is by means of the needle valve 7 seating at the bottom of the slight well. Both common and auxiliary air is supplied from the one source passing by the controller or choke throttle 11 located in the air intake, after which it divides. Constant air passes down through constant air passage 3, thence up through the venturi tube at which point it becomes thoroughly impregnated by a gasoline spray from nozzle 8. From the nozzle it then continues up where it is reunited with the auxiliary air admitted by bronze balls 2. These balls comprise the auxiliary air valves and admit air as required by the varying motor speeds.

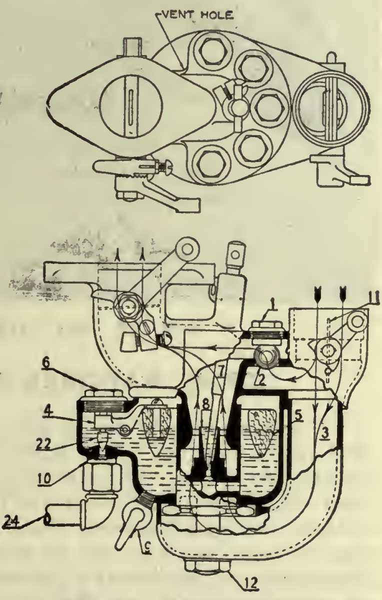


Fig. 245. Kingston Model E.

These balls, after being lifted from their seats, remain floating in the air as long as the vacuum or suction is sufficient to carry their weight. When the

suction decreases with the motor speed they return to their seat thus shutting off the auxiliary air which is not needed at the lower engine speeds. The controller or choke is so placed that it is possible to cut off nearly the entire supply of air. This makes starting in extremely cold weather possible due to the high degree of vacuum produced at the venturi and the rich mixture which is consequently drawn in.

Facts to Remember.—It is essential that the level of the fuel in the bowl is constant and of proper height; that is from 1/32" to 1/16" below the top of the fuel nozzle 8. This may be ascertained by removing the two caps No. 1 and balls 2 opposite each other to permit light to enter one of the holes. Under no circumstances use an open flame for this inspection. The level may be seen through the side opposite the one the light is reflected in. Needle valve 7 should be removed before attempting to check up the gasoline level. Should the level be found too high, bend the float lever 4. If too low, raise it in the same manner. The main reason for keeping the level rather closely adjusted is to assist in easy starting.

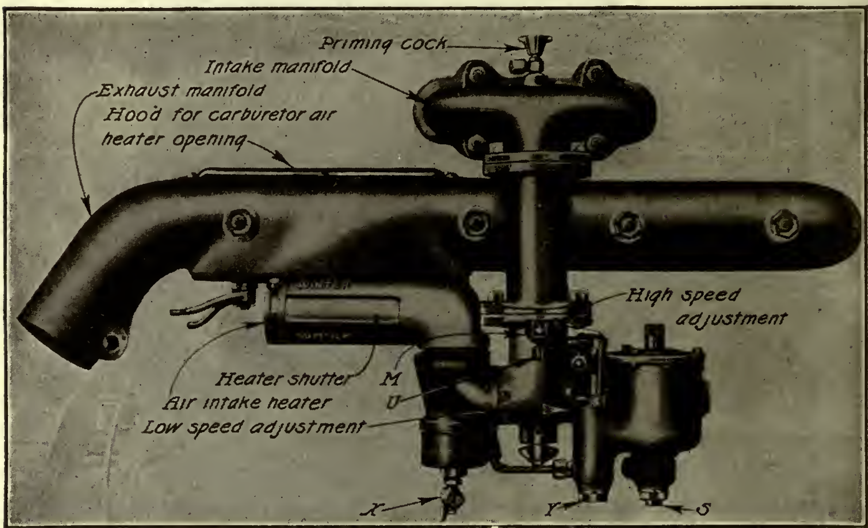


Fig. 246. Reo Rayfield Carburetor and Heater.

JOB 89. RAYFIELD CARBURETOR MODEL L L 3P.

The illustration of the carburetor and manifold, (Fig. 246), is the equipment used on the Reo Car. The Rayfield Carburetor is provided with two gasoline adjustments, but no air adjustment. The student or mechanic should bear in mind that both adjustments are turned to the right for a richer mixture as indicated on the adjustment screw heads. As in all cases, the mechanic should make certain that there are no obstructions in the gasoline lines, that manifold connections are absolutely tight and free from air leaks, that valves and ignition are properly timed, and that there is a hot spark in each cylinder. Always adjust the carburetor when the motor is warm as in service conditions and have the steering column control set at run position. Low speed adjustments must be completed before attempting to set high. Adjustments made for high speed will not in any way affect the low speed adjustments. A low speed adjustment

must not be used to secure a high speed mixture. The adjustments of the Rayfield once set can not change as they are positively locked.

Adjusting Low Speed.—With the throttle closed and the control on run position, close the nozzle needle by turning the low speed screw to the left until the block U slightly leaves contact with the cam M. Then turn to the right for about three complete turns. Start the motor (see starting instructions), and allow it to run until warmed up to a temperature of about 170 degrees. After the motor has become thoroughly heated, push the control lever all the way over on the run position. Then, with retarded spark, close the throttle until the motor runs slowly without stopping. Now, with the motor thoroughly warm, make the final low speed adjustment by turning the low speed screw to the left until the motor slows down and then turn to the right a notch at a time until the motor idles smoothly. If the motor does not throttle low enough turn the stop arm screw A to the left until it runs at the lowest number of revolutions desired. The quality of the mixture can be tested as follows:

With the shutter of the heater body open, it is possible with the finger to press gently on the air valve so as just to unseat it and admit more air into the carburetor. If the motor begins to pick up in speed it indicates that the mixture is too rich. Turn the adjusting screw a notch or two to the left for less gas. Open the throttle, allow the motor to speed up, then close the throttle. After the motor steadies, repeat the operation. If the motor begins to die immediately when the air valve is opened in the manner outlined above, the mixture is too light. Turn the screw a notch or two to the right for more gas. Wait a few moments until the new mixture has had time to enter the motor and repeat the operation again. When the mixture is right the motor will hold its speed for several seconds after the air valve is opened in this manner before it begins to die gradually.

Adjusting High Speed.—Advance the spark about one-quarter way. Open the throttle rather quickly. Should the motor backfire it indicates a lean mixture. Correct this by turning the high speed needle adjusting screw to the right about one notch at a time until the throttle can be opened quickly without the motor backfiring. If loading or choking is experienced when running under a heavy load with the throttle wide open it indicates a mixture too rich. This can be overcome by turning the high speed adjustment to the left.

Starting Engine With Rayfield Carburetor.—Close the throttle and hold the carburetor control all the way over on the starting position. When the motor starts firing, open the throttle slightly and return the control to the running position as fast as the operation of the motor will permit. If returned too quickly before the motor has warmed up the lack of heat and consequent poor vaporization will cause backfiring and popping at the carburetor. When the motor is warmed up the lever must be set and left on the run position, or the rich mixture drawn in will cause trouble with the lubricating system. This trouble is due to the excess or unburned gasoline finding its way down past the pistons into the crank case and thinning out the oil. Where this condition does obtain, the oil should be drained each 500 miles and replaced with fresh oil.

Priming for Starting.—When the lever is in the starting position it is advisable to inspect the carburetor from time to time to determine that the steering column control when set at start pulls the eccentric arm on the carburetor back far enough to depress the small primer plunger on the carburetor. This plunger, when down, opens a bypass to the float chamber, thus permitting the motor when starting to draw gasoline directly from the bowl. The student will readily understand the reason for keeping this closed when the car is in service, as the vaporization of the low grade gasoline in use

is very difficult except with the proper amount or degree of vacuum, heat and atomization as explained earlier in the chapter.

General Information on the Rayfield.—The nozzles should never under any circumstances be changed. The float level rarely needs attention. The automatic air valve is always closed at low speeds or when the engine is not running. Never adjust a carburetor unless the motor is hot. The float chamber should be drained occasionally through plug Y to remove water and sediment which may have accumulated. Also occasionally flush out the dash pot through the drain cock X.

To clean the strainer trap at the bottom of the float chamber shut off the gasoline supply and remove the nut S. Next remove and clean the gauze. In replacing the trap be certain that the gaskets are in place and that the nut is drawn up firmly to insure a tight joint. The trap may be drained only by shutting off the gasoline supply and removing the plug.

Hot Air Regulation.—As stated previously, the present fuel conditions require the application of heat to the carburetor. More heat is needed in winter than in summer if perfect vaporization of the fuel is hoped for. The upper automatic air valve opening of the Rayfield carburetor is connected to a heater which is provided with a shutter for controlling the air temperature. The heater body is marked in raised letters Winter and Summer. During warm weather the shutter should be turned to the Summer position. When so turned the shutter cuts off the heater and allows the air to be drawn through the sides of the heater body. When the shutter is moved to the Winter position it seals the sides of the heater body and compels the air to travel through a channel formed in the exhaust manifold. It is obvious that the temperature of the air is greatly increased by passing through this stove or heater. An opening is also provided for the constant air supply in the hand hole cover which is connected to the carburetor by a tube.

JOB 90. ZENITH MODEL L PLAIN TUBE COMPOUND NOZZLE.

The Zenith Model L is designed on the principle discovered by Baverly. It consists of a float chamber, a carburetor or mixing chamber, a system of nozzle and air passages, and a hot air sleeve and regulator. Gasoline from the tank or feed line enters the body through the strainer D, passes through the filter screen D1, enters the float chamber through the needle valve seat S, lifting the float F. As soon as the gasoline reaches a predetermined height in the float chamber the metal float F acting through the levers B and collar G2 closes the needle valve G1 on the seat S.

From the float chamber the gasoline flows through three different channels in various quantities and proportions according to the size of the nozzle, speed of motor, and degree of throttle opening. With the throttle fully open most of the gasoline flows through the channel E and main jet G. Some flows through compensator I which is located at the bottom of a well open to the atmosphere. This well is left open to atmospheric pressure in order that the suction may have no direct effect on the amount of gasoline coming from the compensator I. This amount is just what will flow through a hole of fixed size and not what might be forced or drawn through. From this point the gasoline flows through the channel K to the cap jet H which surrounds the main jet. The main jet and cap jet work together to furnish the proper mixture whatever the speed of the motor may be.

Idling Device.—At low speed when the butterfly valve T is nearly closed, the main jet and cap jet give little or no gasoline. However, since there is

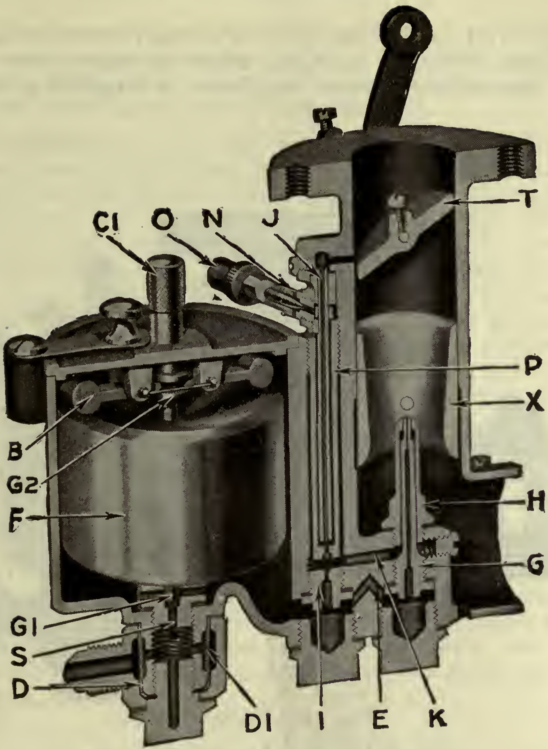


Fig. 247. Zenith Carburetor in Section.

considerable suction on the edge of the butterfly the gasoline is drawn through the idling device.

This device consists of the idling tube J within the secondary well P inserted in the first well, at the bottom of which the compensator I is located and which is open to the atmosphere through holes provided a small distance below the idling screw O.

Gasoline from the compensator I flows through the calibrated hole in the bottom of the secondary well P. This is open to the air through the idling screw O and idling seat N. The idling tube J leads to a hole located at the edge of the butterfly throttle valve where the suction is most strongly felt. This suction lifts the gasoline through the idling tube. This amount of gasoline combined with the air passing the butterfly valve forms the idling mixture.

Air Sleeve.—The air sleeve is provided with an air strangler and temperature regulator. The two large rectangular holes can be closed partially or wholly by the brass band held together by a knurled headed screw. In Fig. 248 the regulator is shown half open. The air strangler or choke is operated by a lever from the instrument board and has a coiled spring integral with it to return it to open position when its use is not desired.

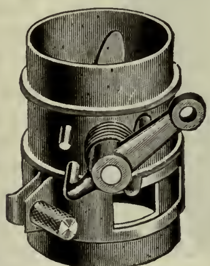


Fig. 248. Zenith Air Sleeve.

Adjustments.—The choke X, main jet G, compensator I, and secondary well P, need not as a rule be disturbed. Their adjustment consists of

finding once for all the different sizes or settings for air or gasoline passages suitable for the motor in question. These passages never vary and once correct will stay correct. Where the Zenith is furnished as standard factory

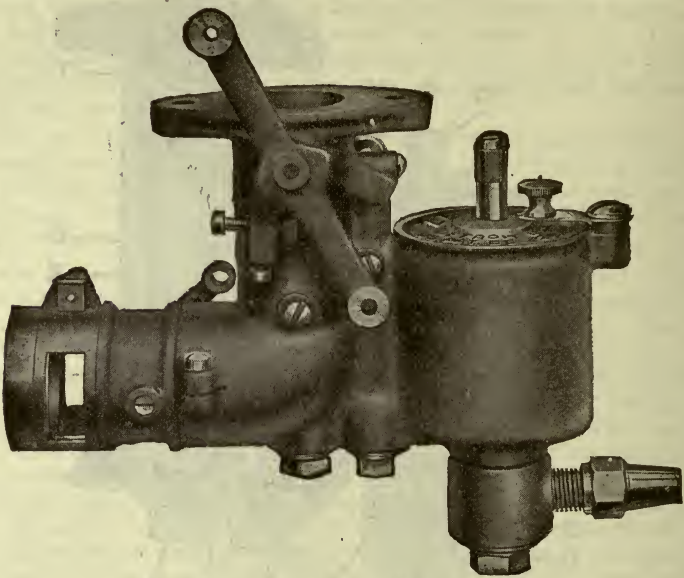


Fig. 249. Zenith Model O.

equipment the settings are correct. This applies particularly for the high speed adjustments.

Slow speed Adjustment.—The only adjustment which may be useful is the slow speed adjustment. The strength of the suction in the idling tube can be

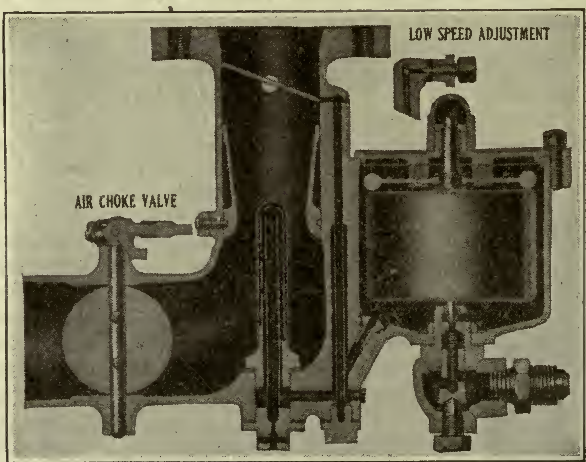


Fig. 250. U. S. A. Standard Military Truck Class B Carburetor.

decreased by turning out screw O, thus admitting more air. Turning in the screw O increases the suction thereby causing the jet to flow more gasoline, making the mixture richer. It should be remembered that this effects the idling speed only and has no effect on the high speed adjustment.

Care of the Carburetor.—In any car, especially the new ones, the gasoline lines and tank may give off scale rust, etc., which will accumulate in the filter causing a stoppage of gasoline flow and consequent popping and missing of the motor. Water will also cause trouble. In this case the carburetor and pipes as well as the supply tanks must be cleaned thoroughly. The carburetor must be completely dismantled to give it a thorough cleaning, but in the case of the Zenith there are no adjustments which can be affected by so doing. If cleaning is necessary be certain to have the float cover well seated, the needle valve seat and various jets screwed down tight as well as the butterfly throttle fastened properly on the shaft, so that it may open fully. When closed, the lower edge of the butterfly throttle should close the idling hole.

To see if there is gasoline in the carburetor remove the needle valve cap C 1. If the needle valve can be depressed with the finger, there is no gasoline in the carburetor.

JOB 91. U. S. A. STANDARD CARBURETOR.

This carburetor shown in Fig. 250 is used on some of the Standardized Military Trucks, Class B. It is of the plain tube Compound Nozzle type. The Stromberg Plain Tube and the Zenith were also used on these trucks. The principle of operation is similar to that of the other plain tube types. The section shown illustrates the method of assembly as well as the type of nozzles and gasoline passages.

JOB 92. CADILLAC CARBURETOR.

This carburetor is a distinctive Cadillac design. It is located in the channel between the two cylinder blocks and is of the single jet type. The float bowl is directly under the mixing chamber and might in fact be said to surround the lower part of it. This insures the proper gasoline level at any angle the car may be in. In other words, steep grades and high crowned roads have no effect on the heighth the gasoline rises in the spray nozzle. Consequently the mixture is not affected by these causes as is likely when the float bowl is to one side of the carburetor. A ring shaped cork float encircling the nozzle is used. The usual float valve mechanism is used to maintain the proper gasoline level.

Primary Air.—The intake for this is an oblong shaped opening in the side, from which the current of air is deflected to the bottom of the funnel-form strangle tube. The venturi effect of the latter gives the inrushing air the high velocity necessary to atomize the fuel and thoroughly charge the air with fuel particles.

Auxiliary Air.—As in all single jet carburetors the auxiliary air valve must be depended on to maintain the proper proportions of air and gasoline at high speeds. In this case the valve is a leather seated swing valve closed by spring action. The tension of this spring is light and sensitive.

Automatic Leaning Device.—The attainment of the desired mixture is further assisted by means of the automatic leaning device. This works as follows. Attached to the right hand of the throttle shaft is a shutter which covers a slot in the side of the carburetor body, whenever the carburetor

throttle is opened to a point at which the mixture threatens to become too rich. When this slot is covered a passage is formed from the mixing chamber to the carburetor bowl resulting in lowering the atmospheric pressure in the latter. This would cause a partial vacuum in the bowl and result in less pressure being exerted on the gasoline to feed or force it through the nozzle into the mixing chamber. This principle was explained under the vacuum tank principle of operation. An adjusting screw is provided for regulating the opening of this passage, and thereby the proportion of fuel in the mixture when the port is opened.

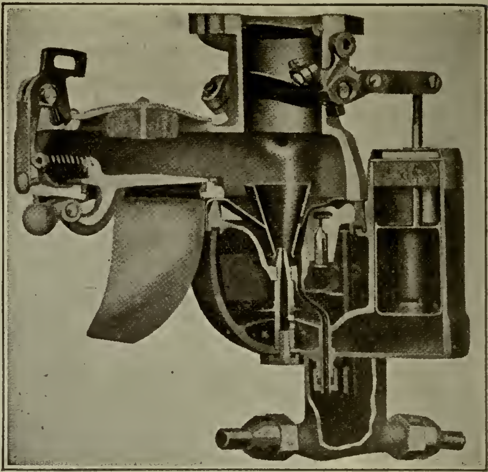


Fig. 251. Sectional View of Cadillac Carburetor.

Starting.—To insure a rich mixture in starting, provision is made to increase the pressure or tension on the air valve spring. As usual, this is controlled by a device on the steering column.

Plunger Pump.—At the moment of acceleration a richer mixture is needed. This requirement is met with a plunger pump operated in conjunction with the throttle lever. In action it forces the needed fuel through the nozzle. Opening the throttle slowly has no effect on the amount of fuel sprayed from the nozzle but when the throttle is opened quickly the plunger exerts an additional pressure on the gasoline in the bowl and causes more to be sprayed out through the nozzle into the mixing chamber. The student will note that leaning the mixture is secured by decreasing the pressure on the gasoline in the bowl which results in a decreased charge being sprayed out, and a richer mixture is secured by adding pressure to the surface of the gasoline in the bowl. Both actions are such as to leave the supply normal for normal speed and requirements.

Throttle.—This is of the usual type and is controlled by either hand or foot accelerator. An auxiliary throttle is supplied to hold the throttle and air valve steady when the car is running at slow speeds with wide open throttle. Heat is secured from the water jacketed intake manifolds. A gasoline drain is provided to carry away the gasoline left from a flooded carburetor.

JOB 93. STROMBERG TYPE M. PLAIN TUBE CARBURETORS.

While there are several models of this type, the action and adjustment of all is practically the same. The level within the float chamber is maintained as usual. From the float chamber the gasoline flows to the well M, through the needle valve which is adjustable. There are two tubes in the accelerating well, one a sort of standpipe H, and the other a smaller one which is within the first or standpipe and connects to the idling jet K. The latter tube has a small opening in the bottom which connects with the well. The top end or the standpipe H connects with the cross passage N, which feeds the gasoline to the eight small discharge holes in the small venturi tube I. This is located just below the main venturi tube. A rich mixture and not raw gasoline is fed

through the passage N because of the small air opening G, which enters the well M and supplies a certain amount of air with the gasoline that is drawn up the standpipe to the passage N. Holes in the standpipe below the level of the fuel feed gasoline into the standpipe, while holes above the fuel level add air from the top of the well M, thus making a very rich mixture to discharge into the small venturi. At low and idling speeds practically no fuel is drawn

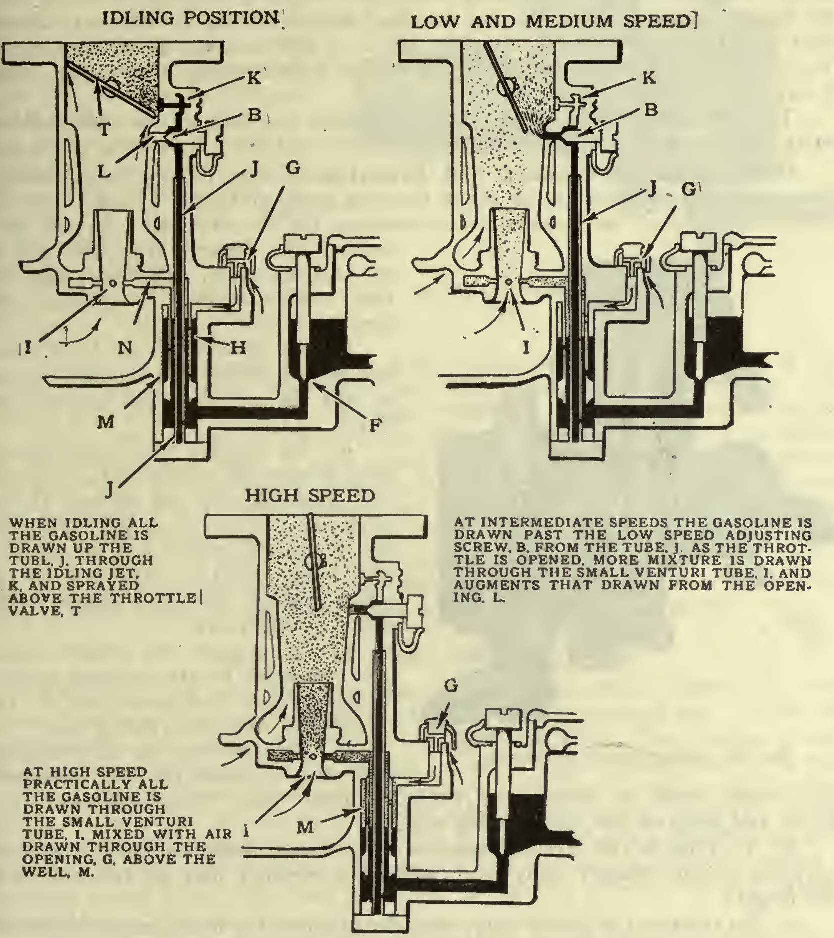


Fig. 252. Stromberg Allen Carburetor.

through the small venturi due to the fact that the passage is closed by the throttle. The gasoline for these speeds is taken through the hole in the bottom of the small tube J, up to the idling needle valve B, thence through the passage K into the intake manifold above the throttle valve. This gives a rich mixture for idling and slow speed running. This action is automatically cut out as the suction increases on an opened throttle. This occurs at about eight miles per hour and thereafter has no effect on the running mixture.

Adjustment.—For running position the carburetor is provided with two adjustments. The screw F is the main adjustment and controls the driving

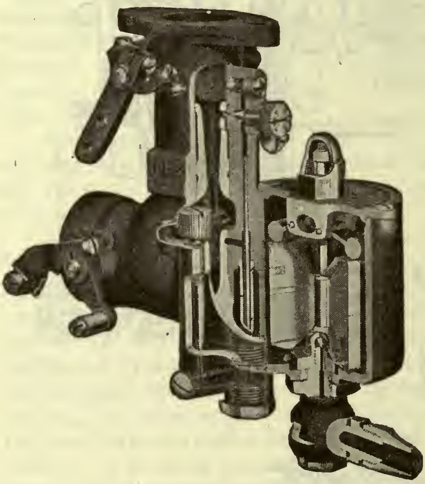
mixture for any speed. If the screw F is turned to the left, or anti-clockwise, the effect is to raise the needle from its seat and give a richer mixture. If the needle is turned to the right, or clockwise, the needle is brought closer to its seat and the mixture is made leaner.

In rare cases an entirely new adjustment is needed. In this case turn the screw F to the right until it seats, then turn to the left or open three complete turns. This should give a mixture much too rich, and from this position with the engine warmed up thoroughly the final setting should be effected. Never start adjusting a carburetor when the motor is cold because of the popping at the carburetor. Always wait until the engine is thoroughly warmed up, when it may be found unnecessary.

The position for the idling screw B is from one-half to one and one-half turns from the seat. Turn to the right for less gas and to the left for more gas.

Dismantling for Cleaning and Repairing.—Refer to the sub-assembly photographic reproduction for aid in locating parts and their names.

1. To remove the throttle valve, unscrew the throttle valve screws, then remove the throttle from the slot in the throttle stem. This will also enable the workman to remove the throttle stem.



No. 253. Stromberg Carburetor.

2. To remove the air horn valve and stem proceed in a manner similar to that for removing the throttle and stem.

3. To remove the large venturi tube, loosen the venturi set screw nut, and unscrew the set screw. If the large venturi tube does not now drop out it may be pulled out by using a wire hook applied to the hole in the large venturi tube just opposite the idling needle valve.

4. To remove the small venturi it is necessary to use a socket wrench inserted from the open top of the carburetor, thus unscrewing it.

5. To remove the accelerating well, first unscrew the idle tube with the holder, using an ordinary wrench of proper size. Next insert a screw driver and unscrew the accelerating well.

6. To remove the strainer unscrew the strainer body stud which permits lowering of the strainer body from which the strainer may be removed with the fingers.

7. To remove the needle valve seat, first remove the float chamber covering by unscrewing and removing the screws holding the same in position. Next remove the float. With the proper size socket wrench unscrew and remove the float valve seat nut. Next remove the strainer body stud and lower the strainer body after which the needle valve seat can readily be unscrewed.

JOB 94. THE STROMBERG ECONOMIZER.

Engineers have found that a mixture richer in gasoline is needed for power at wide open throttle than for ordinary passenger car driving at nearly closed throttle. The difference is dependent on the volumetric charge per cylinder.

With a carburetor giving a single mixture proportion under all conditions,

the best pulling power can be obtained only with a considerable waste of fuel during ordinary closed throttle driving. Also, the operation of a motor on wide open throttle is very much more sensitive to low temperatures than on a closed throttle. The average driver, not wishing to waste time while the motor warms up, sets the mixture unduly rich in the winter.

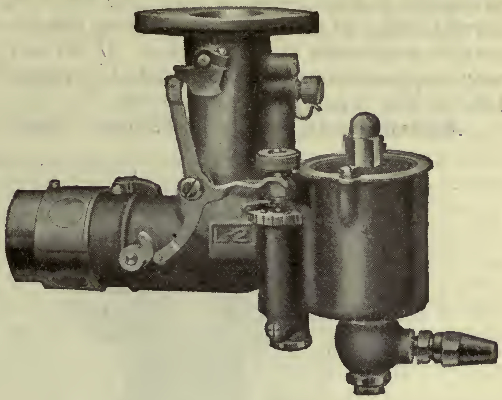


Fig. 254. Stromberg Economizer.

To overcome these difficulties is the purpose of the Stromberg Economizer as applied in Type L. This economizer graduates the gasoline adjustment positively and definitely to the point of highest efficiency for each throttle position.

Action of Economizer.—The high speed needle is held by a nut which is supported by the lever arm at closed and open throttle. The proper needle adjustment for wide open throttle is thus obtained with this nut.

But, with the throttle in ordinary driving positions ranging from fifteen to forty miles per hour, a roller drops into the cam notch which permits the lever arm to drop free so that the high speed nut is then supported upon the economizer nut. This lowers the high speed nut into its orifice and partially cuts off the gasoline for these speeds.

The amount of drop can be regulated by a pointer which thus gives a special adjustment for greatest economy at these speeds. This is so arranged that it has no interfering effect on the maximum power adjustment.

JOB 95. DODGE CARBURETOR.

Action.—From the float chamber the gasoline flows through a small passage over to the compartment at the base of the metering pin. It fills this compartment and rises part way up the aspirating tube. The suction created by the downward travel of the pistons in the cylinders causes the air to rush into the mixing chamber around the aspirating tube and draw up the gasoline. Here the gasoline is vaporized in the manner previously explained, in the former part of this chapter. The air inlet is a short tube to a chamber between cylinders 2 and 3, which in turn is connected to the hot air stove by means of another short tube. The hot air stove is on the exterior of the exhaust manifold.

The proper proportion of air and gasoline is controlled by means of an auxiliary air valve. This air valve is actuated by the suction of the engine. The higher the speed, the greater the suction, and the higher the air valve is lifted from its seat. The air valve returns to its seat from gravity and is not controlled in any measure other than suction to lift it from its seat, and weight or gravity to return it to its seat. On slow speeds all air needed is admitted through holes drilled in the air valve, but as stated previously the air valve rises as speed and suction increase. Another important function performed by the air valve in rising is the lifting with it of the aspirating tube. This action permits the additional amount of gasoline being admitted to compensate for the additional air and to be mixed with it to give a proper fuel charge.

Hence, the higher the aspirating tube the greater the supply of gasoline permitted to flow between it and the metering pin over which it sets. On the correct shape of this tapered metering pin depends to a very large measure the correct proportion of the mixture. If, for any reason, this pin or the aspirating tube has been damaged they should be replaced with new ones. The aspirating tube in this case is the spray nozzle.

Adjusting.—If trouble is definitely traced to the carburetor the first test

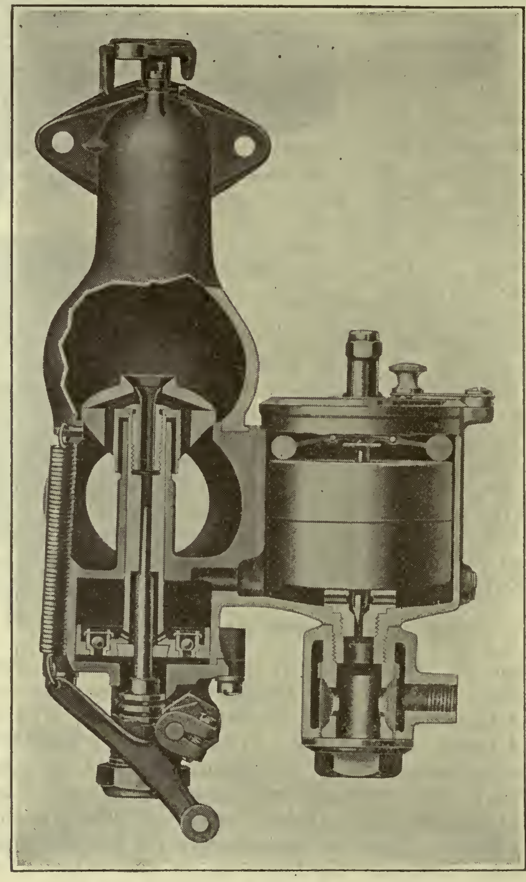


Fig. 255. Dodge Stewart Carburetor.

is to place a film of oil around the union of the flange with the cylinder block. Observe whether this oil is drawn into the engine. If gasoline is used to make this test the engine will show a change of speed if there is a leak. If a leak is found, tighten the joint. This may require the use of new or shellacked gaskets. If the carburetor does not respond properly now, remove and disassemble it. Carefully clean the float chamber of all dirt and sediment. Clean the valve mechanism and the dash pot of all dirt, sediment and corrosion. See that the air valve works freely on its guides.

But one adjustment is provided on the carburetor. This adjustment varies the relative heighth of the metering pin to the opening of the aspirating tube

or spray nozzle. When the dash control ratchet is in, the adjustment is supposed to be correct for running. There is little chance of this getting out of adjustment, but if it does the point at which it should be located may be found as follows.

The tapered metering pin is subject to control within fixed limits by means of the dash control ratchet located on the instrument board. This is for starting purposes when a rich mixture is required. If it has been determined that the fixed setting of the metering pin needs adjustment this may be effected by turning the stop screw to the right or left as desired. Turning this screw to the right lowers the position of the metering pin, allowing more gasoline to be admitted to the spray nozzle, thus enriching the mixture. Turning the screw to the left raises the pin in the nozzle thus cutting off part of the opening and making the mixture leaner. The mechanic must keep in mind that a very small part of a turn on the screw is all that is needed to effect a change in the setting. If the carburetor sputters or backfires at high speeds the mixture requires more gasoline. If the engine loads and pulls unevenly the mixture is too rich.

Air Inlet.—As in most cases the Dodge carburetor secures part of the heat needed for vaporization from the exhaust through a hot air stove. This tends to prevent condensation and assists very materially in maintaining the correct mixture at all times. The temperature of the incoming air can be regulated by means of the adjustable shutter on the inlet tube. In very hot weather or climate the tube may be left off entirely without harm. At times changes of adjustment of the cold air shutter require corresponding changes of the stop screw adjustment as suggested in the previous paragraph.

Draining and Cleaning.—First drain the vacuum tank. Next unscrew the filter cap and screen as well as the cover from the float chamber. The needle valve should be lifted from its seat. This allows the gasoline to flow out and wash out any sediment, dirt and water which may be lodged in the float chamber and permits cleaning the filter screen and other parts. Inspect all parts by removing the float. Give particular attention to the needle and needle valve seat to see that they are free of dirt, smooth and polished.

Throttle and Controls.—The controls are of the type found on the outside of the steering column. No particular attention is needed more than to see that the gasoline control is so set as to give action on opening the hand throttle. The car is controlled very largely by the foot throttle or accelerator. The throttle is of the usual butterfly type. It has nothing to do with the proportions of the mixture but determines the speed and power of the motor merely by the greater or lesser amount of the mixed fuel charge admitted to the cylinders.

JOB 96. BALL AND BALL CARBURETOR ON KING CARS.

The carburetor is automatic and the only adjustment necessary is that for idling speed. This adjustment is designed to care for extreme climatic changes only. The carburetor shown in Fig. 256 is what is known as a double carburetor. Some of the parts in the section are shown out of their natural relation in order to make the illustration clear, and to bring the parts all into one section.

Primary Carburetor.—Referring to the figure, 1 is the hot air passage of the primary carburetor containing the choke valve 2. Three is the primary venturi throat connecting the hot air passage with the mixing chamber 6, and containing the gasoline jet 4. Five is another fixed air regulating orifice connecting the hot air passage 1 with the mixing chamber 6, and provided with a spring opposed idling valve 7 which is arranged to control the air when only

small quantities are being used. The throttle valve 8 is of the usual type. These parts constitute those operative in the first stage of carburetion.

Second Stage.—Referring to the figure again, 9 is an air passage leading from the external air to the mixing chamber 6. This passage contains the butterfly valve 10 which controls the flow of air through this passage. Eleven is a gasoline jet arranged to discharge or spray gasoline into passage 9 when valve 10 is opened. Opening this valve permits the suction existing in the mixing chamber 6 to become effective on the jet 11. The student will grasp immediately the effect the opening of the valve has on the jet 11 when the car is running. A connection between the butterfly valve 10 and the throttle 8

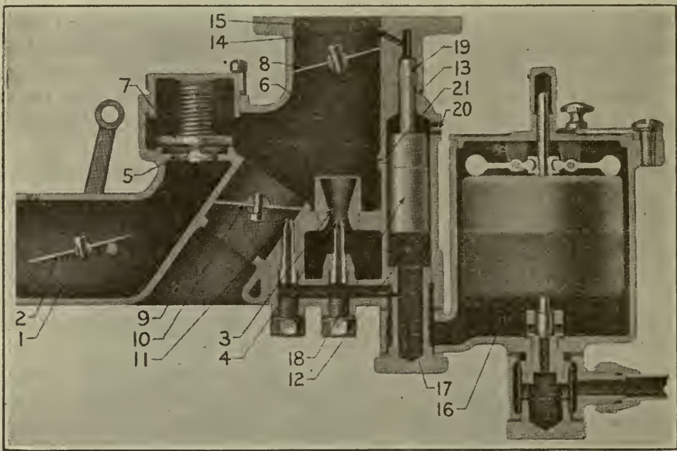


Fig. 256. King Ball and Ball Carburetor.

(not shown) is so arranged that when the throttle is nearly open the further opening of it throws 10 wide open. At all other times the valve 10 is held closed by a spring (not shown). The student will see that the second stage carburetor is not in use except on hard pulls or beyond the average speeds.

Pick Up Device.—Twelve is a cylindrical chamber with an extension 13 of reduced diameter connected to the passage 14 with the chamber 15 above the throttle valve. The chamber 12 is connected with the float chamber 16 by means of the restricted passage 17 so that the gasoline in this chamber stands on a level with that in the float chamber. Eighteen is a loosely fitting plunger with an extension 19 on its upper end forming a plunger in chamber 13. An atmospheric opening is located in chamber 12 while a passage 21 leads from the chamber 12 to the mixing chamber 6 through which passage air is constantly being drawn into the mixing chamber.

In operation on idling speeds it will be seen that the vacuum above the throttle will have the effect of drawing the piston 19 up into the passage 13 and closing the opening 14. However, as the throttle is opened this vacuum above the throttle is decreased and the piston drops, opening passage 14. Gasoline will now find its way around 18 and 19, through 14 to the incoming charge, and give the extra amount of gasoline to insure a quick powerful pickup. This rich mixture is possible for only a short time, however, since the hole 17 is calibrated and only permits of a certain rate of flow since the well 12 is open to atmospheric pressure at 20. This is a type of the compound nozzle carburetor.

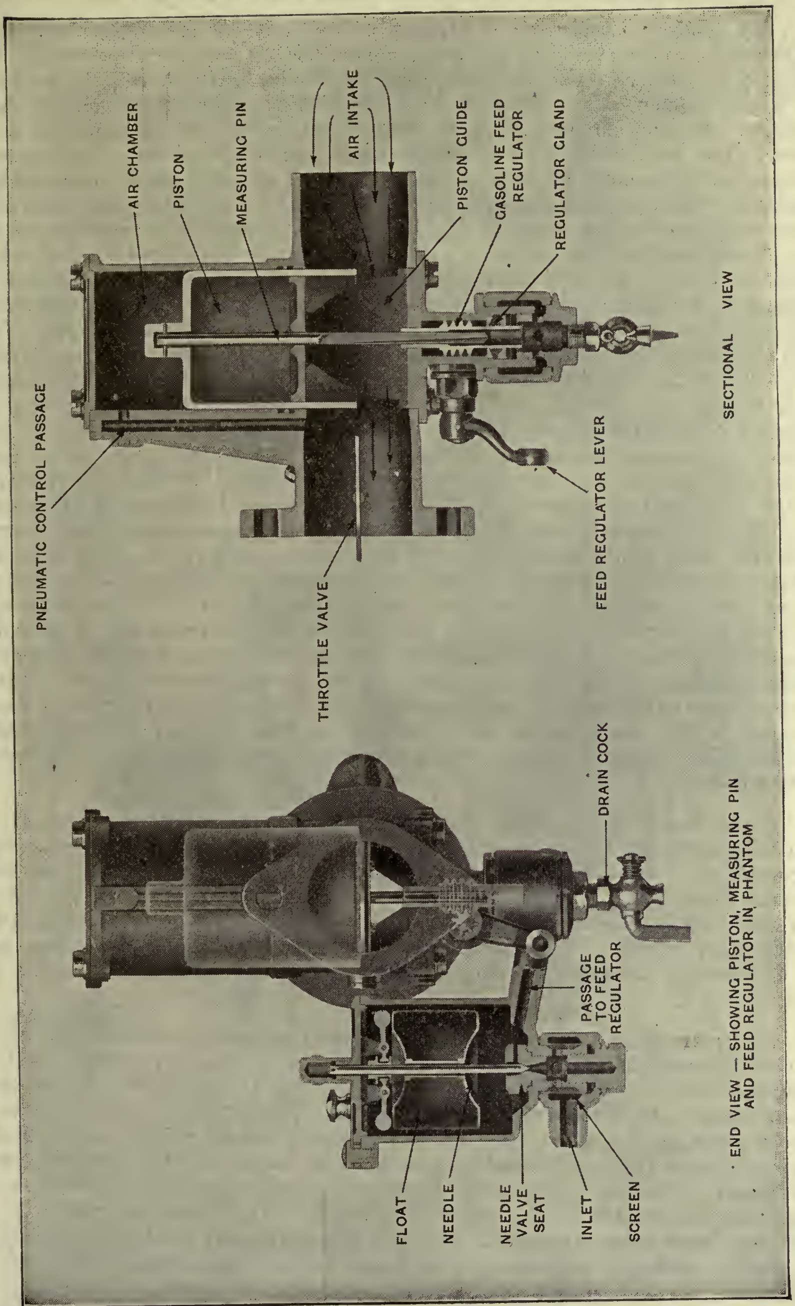


Fig. 257. Hudson Super Six Carburetor.

JOB 97. HUDSON SUPERSIX CARBURETOR,

The Hudson carburetor is especially designed for the Super Six. It is essentially a carburetor for high speed work although it has a wide range. The throttle adjustment must be so set that the engine will idle without stopping as would happen if the butterfly or throttle valve were permitted to close entirely. This adjustment, as in all other types, is effected by means of a set screw. The carburetor is so designed that it can be depended on to properly proportion the amount of air to the gasoline at all speeds without the attendant starving or overfeeding. The carburetor is said to be pneumatically controlled since no action of the operator can change the proportion of gasoline to the air. The butterfly valve might be said to be the cock or faucet turned to admit more or less of the fuel mixture. If more power is needed the throttle is opened more widely, if less power is needed the throttle is closed partially, or wholly. This is regulated by the driver as he actuates the accelerator. The width to which the throttle valve is opened controls the amount of air passing to the engine. This amount of air in turn automatically controls the proportions of air and gasoline entering the mixing chamber and consequently the strength of the fuel charge entering the cylinder, In this way it will be seen that, upon opening the throttle suddenly at low motor speed, the requirements of the motor are comparatively small and the suction of the motor is relatively weak. This suction controls the mixing of the air and gasoline pneumatically by lifting a piston device which measures the correct amount of mixture required and permits it to pass on its way to the carburetor. The necessary velocity as well as vacuum at the mixing device is controlled by the piston and gives perfect vaporization without being compelled to use an excess of gasoline to obtain this result. In other words, the increase and decrease of amount of mixture used determines the size of the mixing chamber as well as the proportions of the gasoline drawn up to be mixed with the air passing through the carburetor at any specified engine speed. The features incorporated in this design which are illustrated in Figs. 257 and 258 have a very decided effect in improving the pulling qualities of the Hudson motor especially at low speeds.

Aside from the periodical cleaning out of the screen at the base of the float chamber and draining off any water and sediment which may have accumulated, there are no intricate adjustments necessary. The gasoline measured out by the measuring or metering pin may be controlled by the gasoline feed regulator connected to the lever on the dash. In cold weather it is necessary to use a richer mixture than in warm weather as is the case with all carbureting devices. For high altitudes proportionately less gasoline will be used.

The amount of gasoline used is dependent entirely on the ability of the driver to handle the dash lever controlling the proportion of gasoline and the throttle to meet needs of travel. High speed and fast work on hills requires more gasoline than moderate rates of speed. The mixture may be set to as lean a point as desired by the driver but some loss of power will be noted. Slower acceleration will be the result. The cause of this was explained previously. There is just so much power in a drop of gasoline. More than the limit may not be taken, less than the limit may be taken and quite often is. A rich mixture is poor economy. Too rich a mixture will surely give an excess of carbon misfiring and undue wear and tear on vital moving parts. If the operator finds it necessary to enrich the mixture for starting, it should be set back as soon as the motor has an opportunity to warm up. The air control lever should not be in the choke or hot positions after the motor is warmed

to the proper operating temperature. This will result in excessive gasoline consumption because the pneumatic control does not operate freely.

The only attention to this type of carburetor will be to see that the filter under the float chamber is not clogged, thereby restricting the flow of gasoline. The needle valve should be watched that the parts are seated properly to

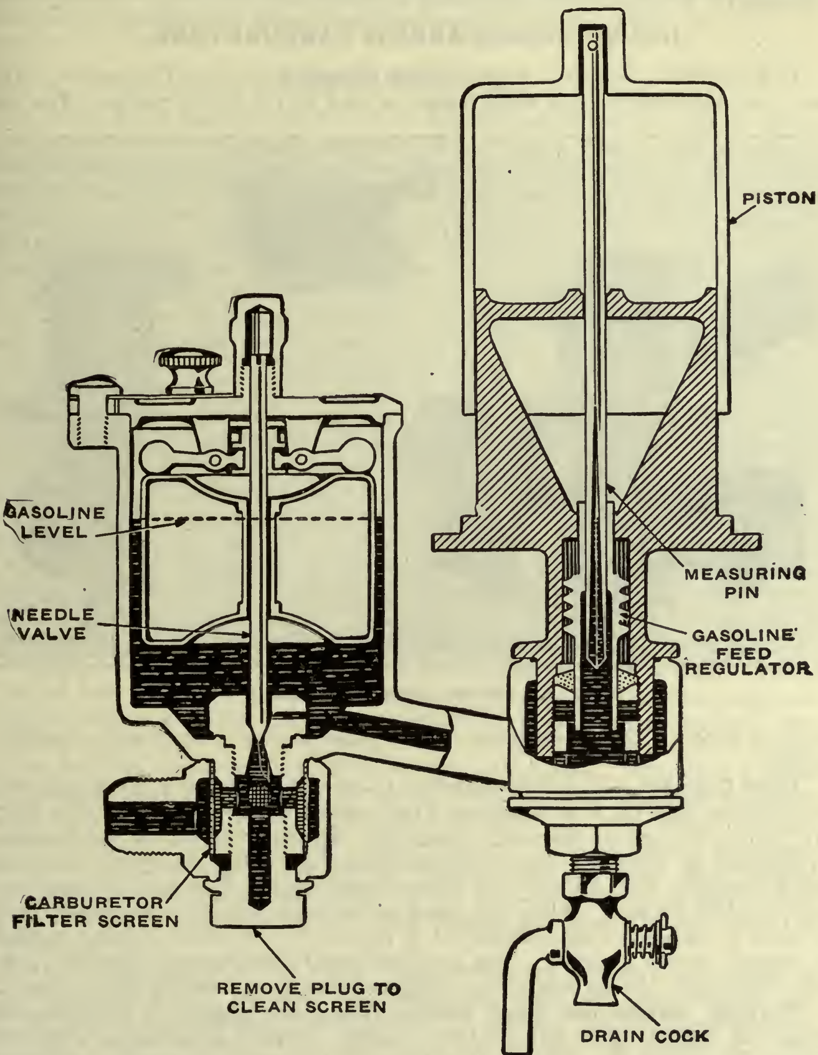


Fig. 258. Hudson Super Six Carburetor.

prevent flooding. It is necessary to note the action of the motor to determine whether or not the piston valve which is the air valve is acting freely. An excessive accumulation of dust from dusty roadways will cause this to stick at times. If the strangler is used for starting, the fact that the valve is stuck may not be noticed. The action of the valve is not absolutely essential to

driving the car, but an experienced driver will recognize the trouble almost instantly due to the fact that the accelleration and power are below normal. The valve may be freed by removing the cover from the valve cylinder and cleaning it with gasoline. In putting back the top it is well to add a little kerosene to flush out any remaining dust as the valve works.

JOB 98. PIERCE ARROW CARBURETORS.

In Fig. 259 is shown the Pierce Arrow Special Automatic Carburetor. The same type, although not the same model, is used on the Pierce trucks. The one

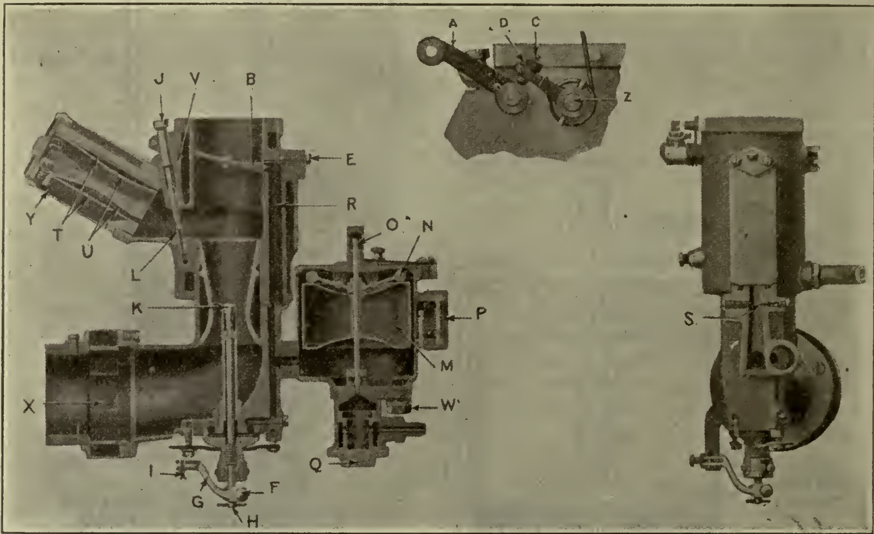


Fig. 259. Pierce Arrow Carburetor.

shown is used on the Pierce Dual Valve passenger car engine and on earlier models.

Float Chamber.—The float chamber is screwed to the carburetor body in a fixed position and the float is adjusted to maintain the gasoline level at a point 5/16″ below the top of the spray nozzle K. The opening in the spray nozzle is regulated by valve H. When the gasoline falls below its proper level the float M together with its levers N drop, permitting the float valve to open and more gasoline to flow. When the gasoline has again come to the proper level, the valve is closed. A glass window P is provided in the float chamber to show the heighth of the gasoline. The gasoline feed is the pressure system. Dirt, water and other foreign matter is held out of the float chamber by the trap Q.

Throttle, Needle and Reed Valves.—When the engine is running very slowly the throttle B is just starting to open. Almost all the air is entering through the passage R. Here it is mixed with an amount of gasoline regulated by the nozzle S. The amount of mixture entering the cylinders at this speed is regulated by the screw E which is really a throttle for the small passage R. The three auxiliary air inlet reed valves are closed. As the throttle B opens more, the suction through R becomes greater for a short period and then becomes the same as through the main passage. As the motor speeds up, the light intermediate and heavy reeds open in succession, admitting more air.

Supplementary Springs and Needle Valve.—The supplementary springs U

form gradual stops of a progressive strength on the reed valves. The distance between the reed valves and the supplementary springs should be, for the light reed 1/8", for the intermediate and heavy valves 5/32". Once set, these reeds require no further attention in adjusting the carburetor. There is a supplementary spray nozzle L provided with an adjustment needle valve J. This only comes into action at high speed when the reed valves are open.

Adjusting Carburetor.

1. Note if the gasoline level is even with the mark on the post or in the sight-glass of the float chamber, the motor not running and the car on a level.
2. Disconnect the throttle rod from the lever and close the main throttle B tight by backing off on screw C. Adjust this screw until it touches lever A at the beginning of the straight surface, then screw in one-half to three-fourths of a turn more and tighten lock nut D. Connect the throttle rod to the operating lever adjusting the length of the rod so the throttle just begins to open.
3. Turn the idling throttle E into the shoulder until the head of the screw seats, then turn back one and one-half turns.
4. Loosen screw F on lever G. Turn needle H to the left, or until it is on its seat. Next turn to the right to open three-fourths of a turn.
5. Start the motor by priming and allow it to run until it is warm. Open the throttle until a motor speed of twenty to thirty miles is obtained. Adjust needle H. When the motor runs best set lever G at right angles to center line tightening screw F. Set the regulator on the steering column in the center. Put wire in lever G tightening screw I. This permits of equal travel each way from the center.
6. Loosen the lock screw on high speed needle J. With the fingers screw down until closed on seat. Next screw back or open until open from three-eighths to five-eighths of a turn.
7. Test the car on the road. It should not be set to run slower than five or six miles. Always keep throttle screw E closed as much as possible. If the car works best at speeds between twenty and thirty miles per hour with the regulator in the center adjustment on needle H the carburetor adjustment may be considered correct. If at fifty miles there is a need of setting it to the heavy position, the high speed needle must be opened a bit farther. If it runs best on light the high speed needle should be closed a trifle as this indicates too much gas and too rich a mixture. When properly adjusted the entire range of speed should be available with one setting of the regulator. It is, of course, necessary to make such adjustments as will care for extreme cold and heat. It is for this purpose that the regulator is provided. Great care should be exercised to see that all locking or clamping screws and devices are properly set after the carburetor is set.

Further Suggestions.—The idling adjustment does not have any effect on other adjustments. It becomes ineffective as soon as the throttle has uncovered the idling passage. With throttle B adjusted and in closed position only a very small amount of air passes up and around the nozzle K. The velocity of the air is so low that no gasoline is drawn from the K or L while the suction or idling passage is very high. The throttle screw E is used to control this suction and velocity.

Best results are obtained by keeping screw E closed as far as possible. As the throttle is opened the idling passage E goes out of action and all gasoline comes from nozzle K in the mixing chamber or venturi. When the speed has reached twenty to thirty miles per hour the high speed valve or jet comes into action and begins to supply the auxiliary gasoline to compensate for the

auxiliary air admitted through the reed valves which are in action as mentioned previously.

For starting in cold weather the gasoline regulator should be put on heavy position. When running on level roads economy may be secured by turning the regulator to light position which means a lighter or leaner fuel charge.

The carburetor is heated in part by means of hot water. A cock is provided to regulate the amount that is flowing. Except in extremely hot weather this should be wide open.

By opening the ventilators in the top of the hood and pulling the hot air funnel away from the exhaust pipe the engine will run cooler. This is rarely needed except in high altitudes. Due to the low grades of gasoline used it is best to keep the engine well warmed up. Just below the boiling point is considered the most efficient temperature. In winter all heat is required which can be obtained. Hot water must be on full, the cold air regulator at the bottom of the carburetor closed, and the hot air funnel brought to within one inch of the exhaust pipe. In addition to this, at least one-half of the radiator must be covered. In colder climates it is well to keep a small portion covered even in summertime.

Care and Maintenance.—If all gasoline passages are clean and free, and all connections on inlet pipes are tight, the above adjustments will give a quick pick-up and the greatest economy. Flooding the carburetor is usually due to dirt under the needle valve within the float chamber. Remove cap screw W and clean it. The screens X and Y should be thoroughly cleaned from time to time. The screen over the air pipe or funnel will gather dust and dirt. This should also have attention.

JOB 99. SCHEBLER DASH POT AIR VALVE TYPE CARBURETOR.

In adjusting the Schebler of this type first turn the auxiliary air valve screw A (Fig. 260) until the air valve seats firmly. Next close the needle valve to

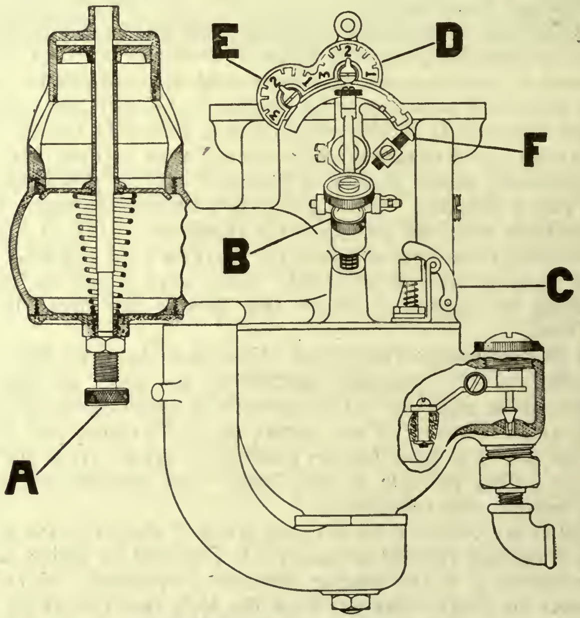


Fig. 260. Schebler Carburetor.

the right until it seats. Do not crowd or force a screw of this nature onto its seat as serious damage may result. Next turn this screw open or to the left from four to five complete turns. Next prime or flood the carburetor by pulling up the priming lever C and holding it up for about five seconds. The throttle should now be set one-third open and the motor started. The spark should be retarded and the throttle closed gradually at the same time adjusting screw B until the motor runs evenly and hits on all cylinders.

When the motor has a good idling speed the intermediate and high speed adjustments should be made on dial D and E. Adjust the pointer on the first dial D from Figure No. 1 toward Fig. 3 about half-way between. Advance the spark and open the throttle so that the roller on the track running below the dials is in line with the first dial. If the motor backfires with the throttle in this position and the spark advanced, the pointer should be moved a little more toward 3, or if the mixture is too rich, turn the pointer toward 1. Continue the manipulation of these parts until you are satisfied that the best action is obtained from the motor for this or intermediate speeds. The adjustment for a wide open throttle is made on dial E in just the same manner as that just described for intermediate dial D.

Further Hints.—It has been found that the tendency is to give the carburetor and engine too rich a mixture. In adjusting for low, intermediate, or high speeds, it is best to cut the supply down until the motor begins to backfire and then increase the supply a notch of the needle at a time until the motor runs well and hits evenly on all cylinders. When by this slow process the point is reached where the engine is running evenly, do not advance further. In making adjustments for high speeds do not turn the pointers on the dials more than one-half of one of the graduations before giving the adjustment a test.

Float Valve Levels.—The top of the cork float should stand 1 1/16″ from the top of the bowl in the one inch, and all models up to the two inch model. The measurement is made, of course, with the valve seated.

ENGINE SPEED GOVERNORS.

Due to the nature of the truck motors in use for heavy duty work it is well to take some precaution against overspeeding them. When a motor is driven above its rated speed for continuous service and over considerable lengths of time the deterioration due to vibration and friction is very high. It is not always the fault of the driver that the motor is overspeeded as a difference of a few miles per hour which is barely perceptible to the driver is the extra speed which quite often does the damage.

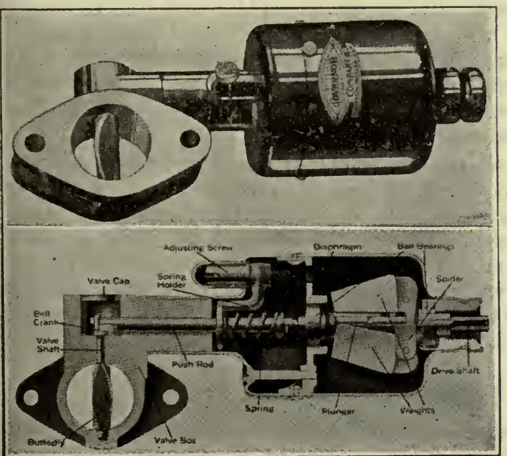


Fig. 261. Pierce Governor.

There are a number of devices on the market designed to control the speed (R. P. M.) of the motor so that overspeeding the motor is a practical impossibility. The Pierce Governor is of this type. Fig. 261 shows how the governor works and how it is assembled.

The governor proper goes between the carburetor and the intake manifold. It may be connected to the driving agent by either a solid or a flexible shaft. In the governor valve box the valve is normally in a position which does not obstruct the flow of the gas, but it is closed so as to reduce the valve port area immediately the motor has reached the predetermined speed. The valve is actuated by what is known as the flyball principle. The two weights are mounted on a spider which revolves on ball bearings. These two weights are so pivoted that as they increase in velocity they swing outward, thus forcing a plunger forward which in turn operates the butterfly valve. The plunger is forced against a spring calibrated to a standard pressure so that as the velocity of the weights decreases they return to normal position and the butterfly opens. The oil required for the governor is supplied through the oil cup in the case. The revolving weights serve to splash this oil to all moving parts. The action is positive and simple and requires little attention other than proper adjustment and lubrication.

INSTALLING PIERCE GOVERNOR.

Begin the installation of the governor by mounting the gears which are to drive the governor shaft. This may be on the motor front wheel or the transmission. To this governor drive is then attached the drive shaft which may be either solid or flexible. Flexible shafts should not be bent closer than two inches from either end, nor in less than a ten inch radius. Do not stretch the tubing or it will develop oil leaks. Should the tubing touch any part of the car frame strap it solidly to prevent wear due to vibration. When solid shafts are used be certain that keys and key-ways engage properly when assembling; also that lock-nuts are tightened after installation is completed.

When mounting a new governor, or replacing a carburetor that has been removed for any reason, use thin gaskets of blotting paper between the flanges. Do not use shellac as it is very likely to make trouble by causing the throttle or butterfly valve to stick. The governor must always be mounted with the oil cup on top.

Oiling Governor.—Before the governor is put into active service, the case should have four ounces of light Polarine or equal oil put into it. Use an oil not affected by temperature changes. Oil should be replenished each thousand miles if the governor is mounted horizontal, oftener if mounted otherwise.

Solid shafts require no lubrication, but gears in angle or motor drives must be kept running in heavy oil or cup grease. Other parts of mechanism should be oiled weekly through oil holes which are provided. For flexible shafts use Arctic No. 3 or good heavy graphite grease.

Regulating Governor Speed.—Since the governor speed controls the truck speed it is sometimes desirable to change the speed adjustment. First cut the wire that seals the adjusting screw and pull off the cap that holds it in place. The adjusting screw is then exposed. Turning the screw to the right, or clock wise, decreases the motor speed. Turning to the left or anti-clockwise increases the motor speed. When proper adjustment has been made replace the cap and seal same. This prevents anyone tampering with the adjustment, and prevents vibration changing it.

JOB 100. CARBURETOR JOBS.

Regrinding Float Needle Valve.—Leaking or flooding is a fault common to all carburetors. While the fault may be remedied, it requires good judgment on the part of the operator. In the first place the automatic mechanism is rather sensitive to dirt. Any small bit of dirt will hold the needle valve open

and allow the gasoline to flow through the valve until it finally rises above the spray nozzle when flooding occurs. This may be remedied by removing the dirt, if dirt is the trouble. If the mechanical fit is at fault it may be remedied as follows:

First remove the mechanism and see that the valve aligns itself properly with the seat. Assured of this, place a screw-driver on the upper end and give a grinding motion similar to valve grinding. Do not use grinding compound or an abrasive. A little oil will be of help. As the valve is rotated to different positions it is sometimes good policy to tap the end of the screw-driver to help the seating action. Needless to say, the blow must be a light tap with a light hammer. A test the mechanic uses, to learn if the valve is seating properly without actually putting the carburetor into service, is as follows: Assemble the valve and float mechanism. Next turn the carburetor bowl upside down or invert it so that the weight of the float closes the valve. Having the gasoline connection in place, the operator places his lips to the fuel connection drawing air from the fuel cavity, thus creating a vacuum therein. If the job is tight the lip will be held by this vacuum, but if a leak is present air will find its way into the fuel cavity and release the lip.

CHAPTER 10

FUNDAMENTAL ELECTRICAL DATA

Without electricity in its applied form, the automobile, while not an utter impossibility, is almost that. Here as elsewhere is found that element of theory which the student must grasp, in order to have the understanding of principles and processes so necessary to intelli-

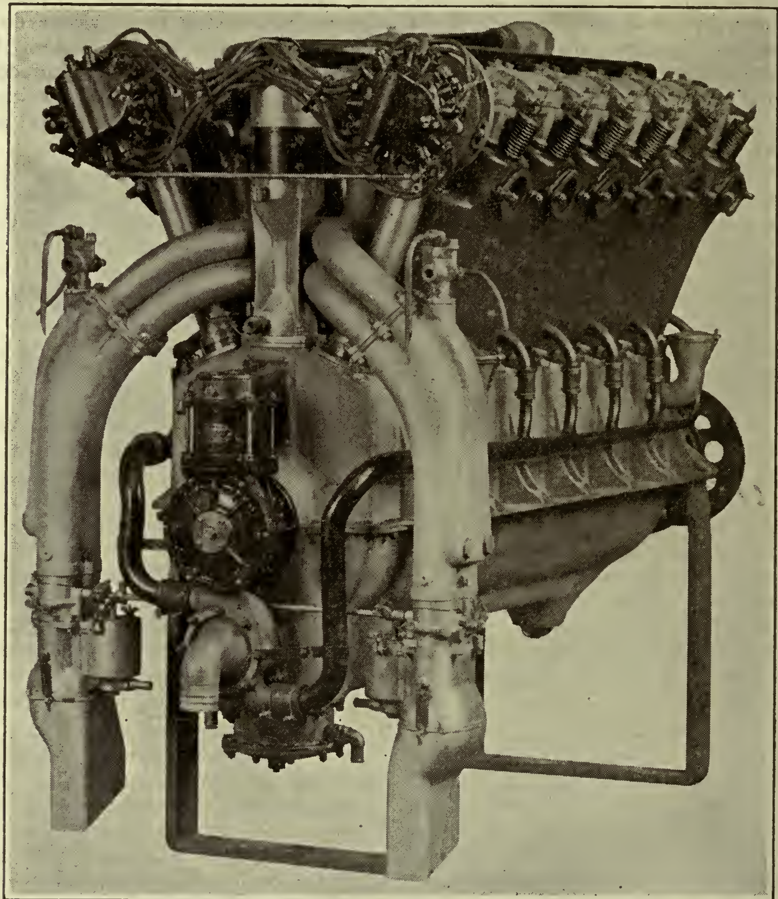


Fig. 262. Packard Liberty Aeroplane Motor equipped with battery ignition units.

gent care and repair of automotive equipment. This is stated with especial reference to ignition, starting, charging and lighting equipment.

Since it has been one of the latter sciences to be developed, its

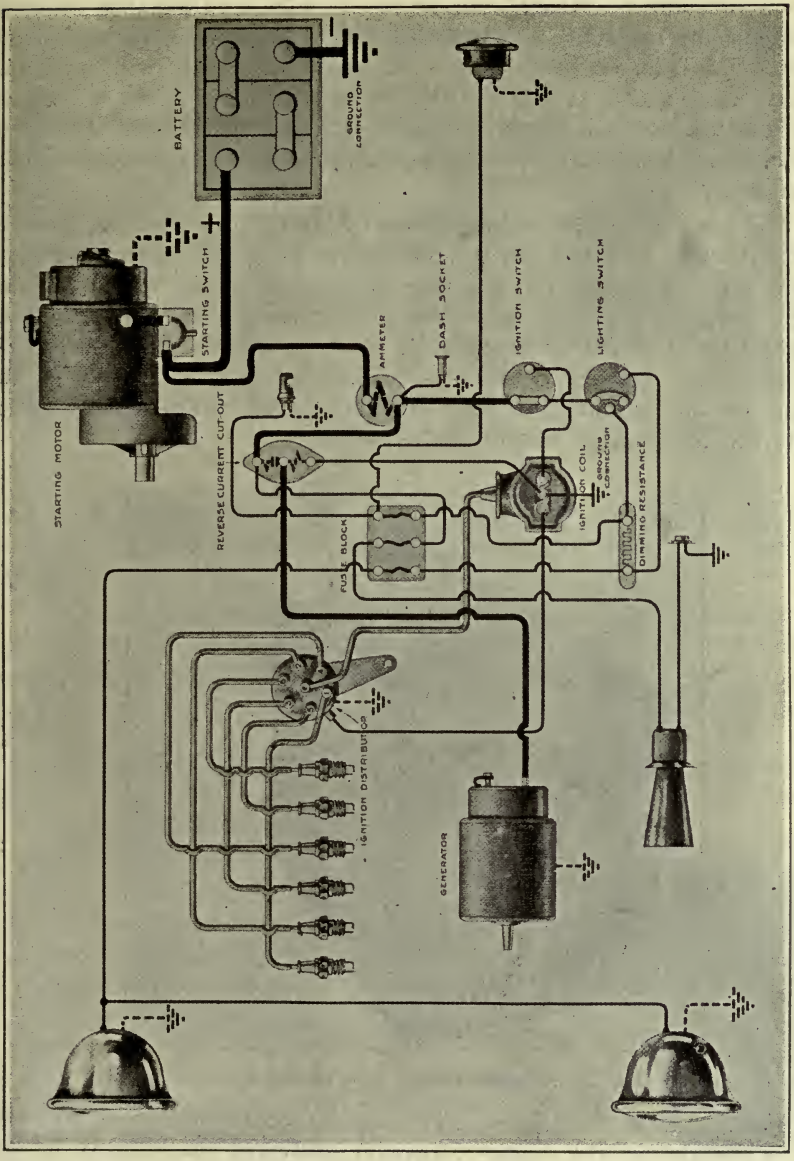


Fig. 263. Typical application of electrical equipment to a motor car.

action is not so largely a matter of every-day thought and knowledge, as are some of the other sciences. Also, there has always been an element of mystery about it in the minds of most people. Perhaps the number of varied uses to which electricity may be put gives some ground for this feeling. It will send the wireless message half-way

around the world. It will receive it. It will send a dozen or more messages over one wire at the same time. It will receive, select and differentiate them at the other end of the wire. It will light our homes; heat them, too, if desired; cook our food, drive our street cars, our electric passenger vehicles, our electric freight trucks, or our electric locomotives more powerful than the greatest steam locomotive.

It drives the innumerable wheels of industry, guides the mariner across the sea, or lifts a ton of steel on the end of a crane. No work is too big, too huge; no task too fine, too delicate, to ask of this public servant, provided only that proper mechanical equipment be supplied for it to act on or through in doing the duty imposed. By providing this proper equipment, electricity is made to light the lamps on the automobile, start the engine to turning, and fire or ignite the fuel charge within the cylinders.

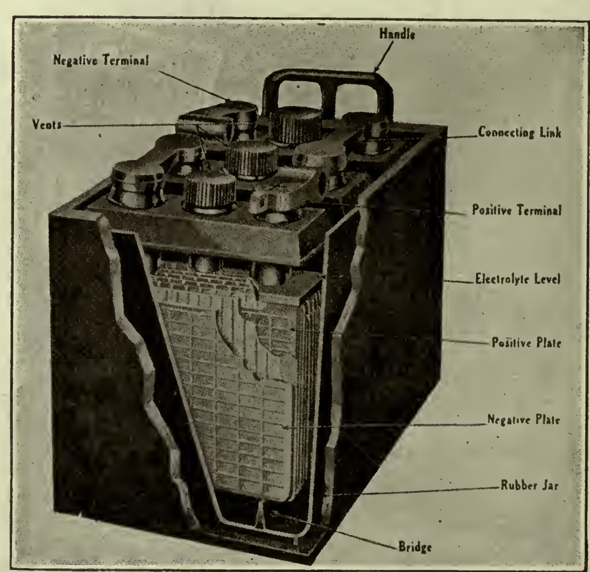


Fig. 264. Storage Battery with section removed.

Fundamental Principles.—The fundamental principles of electricity are always the same. However, different mechanical devices are needed to apply it to the different purposes for which it is used. For instance, current drawn from the storage battery will drive the starting motor, or will light the bulbs within the lamps, or may be used to ignite the fuel charge within the cylinders. The same current performs very different types of work with mechanical devices designed for same. Current electricity is energy, and energy is what is needed to light the lamps, turn the starting motor, or jump the

spark plug points. The student will learn in the following pages how this one form of energy is engaged in doing the varied kinds of work. He will learn as well the laws and principles governing its workings as well as methods of constructing, caring for, and replacing the necessary mechanical devices. Many hours of study as well as many days of work will be needed to fully understand the application of electricity through the various devices to the automotive field. In place of the mystery surrounding its application will come a delightful understanding and a keen appreciation of its powers, its sensitiveness, how it is produced, and its methods of doing work.

Source of Supply.—Electric current may be obtained from batteries or from magnetic lines of force. Batteries may be considered as belonging to several classes as primary and secondary. Each of these may again be divided into several classes or types. Magnetism may be from the natural magnetic lines of force as they flow from the North pole to the South pole over the earth's surface, or from natural lodestones. In actual practice electric current is taken from the magneto, dynamo, or generator armature wires as they are revolved rapidly in a magnetic field produced either by permanent magnets or electromagnets.

Primary Battery.—Primary batteries as used for automotive work are usually the commercial dry cells. Wet cells are not used in conjunction with the automobile. The dry cell is no doubt familiar to the student. It has a pressure of one and one-half volts and an amperage of 28 to 32 when new and in good condition. To increase the voltage a battery of dry cells is set up, which are connected in series. Connecting in parallel will increase the amperage available.

Secondary Battery.—Storage batteries are capable of generating no current within themselves without first being subjected to a charge from an external source which sets up an electro-chemical action within the battery. On being discharged a reaction takes place in the battery. Since no current is available without the initial charge, the battery is called a storage battery. Each cell of a storage battery has a pressure of two volts, this being one-half volt more than the dry cell. The amount of current or amperage available varies within a large range.

Fig. 265. Magneto magnets with pole shoes attached. Note how the magnetic lines of force support the iron filings. The center of the field has few lines flowing. The flux always seeks the closest points to travel between.

Magnetic Lines of Force.—To obtain current from magnetic lines of force a conductor must be made to cut them, and must be arranged in such a manner that as it is cutting the lines of force, the electric current may be

taken from the ends of the conductor. The device used for this is known as an armature and is used in the generator or magneto. A commutator or slip rings are used to take off the current. This is developed in the latter paragraphs and chapters. It is well to remember at this time, however, that the number of lines of force cut and the rapidity with which they are cut determines in a large measure the pressure or voltage, while the amperage or amount of current developed is dependent on the size of wire used to wind the armature, the amount of resistance offered the flow of current, and certain other features of design. The student, if not already fitted with an understanding of electrical terms, is beginning to feel a need of explanation with reference to the simplest of them. He will also wish to know and be able to recognize as well as use the symbols for these terms.

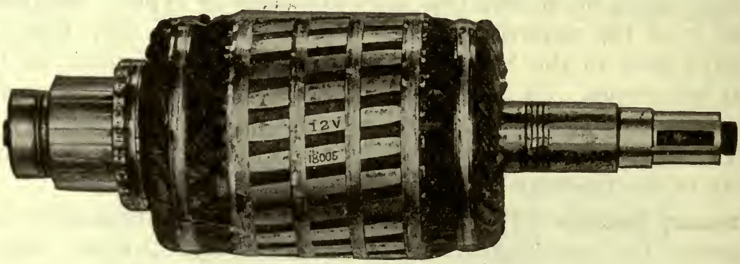


Fig. 266. Drum Armature for Motor Generator.

Volts, Written E.—The pressure, power, or force which causes an electric current to flow along or pass through electrical conductors is known as a volt or volts. A piece of water pipe may contain water but it will not flow until pressure is put back of it. The pounds pressure on water and the volts pressure on an electric conductor are very similar as far as their use is concerned. They are the force causing the element to flow. In the one case volts cause a certain number of amperes to flow along the conductor; on the other hand pounds cause a certain amount of water to flow through the pipe. This is called the water analogy, meaning explanation of electrical action.

Ampere, Written I.—The amount of current carried or forced through the conductor by the voltage or pressure is figured in amperes and is so stated. More amperes can be carried by a large conductor than by a small one, although the voltage may be the same in each case. The large storage battery has a greater output than the smaller one just as a barrel will hold more water than a keg.

Ohm, Written R.—The ohm is the unit of resistance to the passage of electrical current. Even in such conductors as copper there is a certain amount of resistance to the flow of electrical current. For instance, it is easy to drive a nail through a soft pine board. A greater resistance is encountered in hardwoods such as oak or maple,

but if a piece of iron or steel is struck by the nail it is impossible to drive the nail into it.

Electric current passes over or through most conductors very readily, but if a non-conductor is in its path it refuses to pass unless

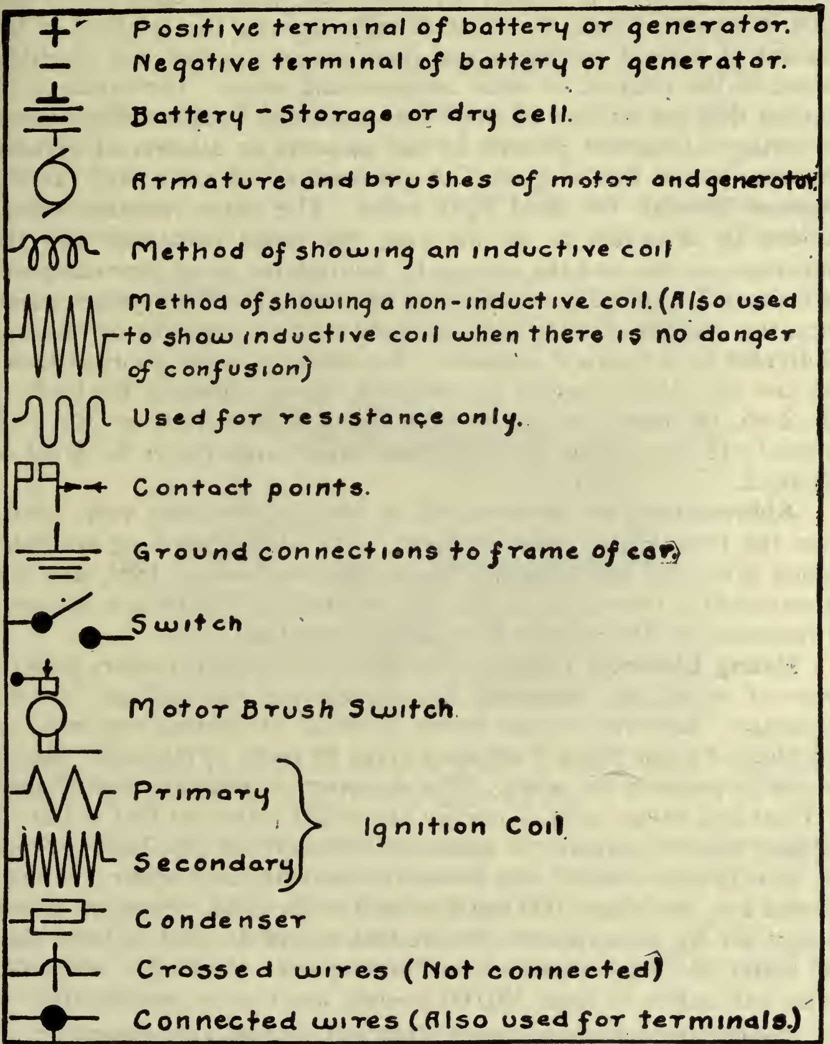


Fig. 267. Method of illustrating conventional electrical characters.

the pressure or voltage is very high. In the case of the nail, if the driving force is great enough, it may be forced through a thin piece of sheet metal, but it is folly to try to drive it into a casting or the anvil. In the case of the electric current, if the voltage, pressure,

or force is great enough, it may be made to penetrate or pass through a non-conductor. This point will want to be held in mind by the student as it has a particular bearing in relation to the subject of ignition. It also has a more general application to insulating or non-conducting materials. Ohm, for whom the law of electrical resistance is named, found that certain rules govern the relation of the amount of current resistance and pressure, or in other and electrical terms, in the relation of volts, amperes and ohms. For instance, he learned that the number of ohms resistance was equal to the pressure or voltage of current divided by the amperes or amount of current. An example of this is given. A pressure of 12 volts will carry 2 amperes through the head light bulbs. The ohms resistance is 12 divided by 2 equals 6; or, knowing the ohms resistance and the amperage, we can find the voltage by multiplying ohms times amperes as 6 times 2 equals 12; or, knowing the voltage and the ohms resistance, the amperes flowing may be found by dividing volts by ohms as 12 divided by 6 equals 2 amperes. Accordingly, in the shortest terms the law is: Volts divided by amperes equals ohms or $E \div I = R$ or $12 \div 2 = 6$, or ohms multiplied by amperes equals volts or $R \times I = E$ or $6 \times 2 = 12$, or volts divided by ohms equals amperes or $E \div R = I$ or $12 \div 6 = 2$.

Abbreviations or Symbols.—E as used to designate volts comes from the term Electro-Motive Force. The abbreviation or symbol I comes from the International Electrical Congress of 1893, and the name in full is International Ampere, written I. The Ohm is the unit of resistance so the symbol R is easily arrived at.

Rating Electrical Power.—The units of energy necessary to do a piece of work are computed by multiplying the voltage by the amperage. Referring to the former problem of lighting the bulb, we find that 12 volts times 2 amperes gives 24 units of electrical energy needed to perform the work. The discovery of this law is attributed to Watt and these units of energy are called watts, so this might be written, volts $\times$ amperes $=$ watts, or $E \times I = W$, or $12 \times 2 = 24$. Since the watt is such a small unit its use is cumbersome and the kilowatt, written kw., meaning 1,000 watts is used in its stead. Since all power ratings are by horse power, the student would do well to learn that 746 watts are rated equal to one horse-power (1 H. P.), since 746 watts will suffice to raise 330,000 pounds one foot in one minute.

Conductors.—Conductors of electrical current are present on all hands. All metals are conductors. Water and some other liquids as electrolyte are conductors. The earth itself is a good electrical conductor. The human body is a fairly good conductor as is evidenced by the ease with which a shock may be obtained when touching a heavily charged body. Copper is used almost universally as the cheapest good conductor. Iron wire is much inferior to copper wire

as a conductor. Larger sizes must be used to carry a like amount of current.

Non-Conductors or Insulators.—Air, stone, mica, porcelain, glass, paraffine, sealing wax, rubber, vulcanite, and certain other substances as silk, cotton, shellac and insulating enamel are good non-conductors, or as generally termed, insulators. By this is meant that they prevent the passage of electric current from one conductor to another.

Positive and Negative.—Batteries are furnished with two terminals or posts to which conductors may be attached to obtain the electric current therefrom. One of these is always termed a positive terminal, marked + (Plus), and the other a negative terminal, marked — (Minus). Current flows out from the positive and through the

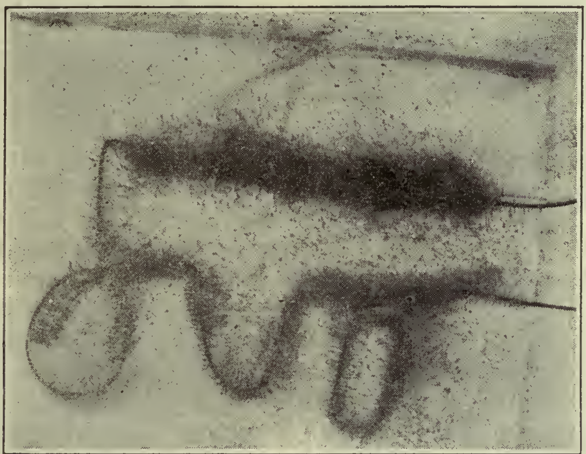


Fig. 268. Around every wire carrying an electrical current there is a magnetic whirl. This is always around the wire and at right angles to its axis. The wire running in many directions shows this. A 12 volt current caused the iron filings to be arranged as shown on the glass. Wire is under the glass.

conductors and instruments returning to the battery through the negative terminal. Some instruments are marked similarly, or they may be marked with the abbreviations Pos. and Neg. The carbon on the dry cell is the positive, while the zinc can, or shell, is the negative. Methods of determining the terminals will be noted from time to time.

Magnetism.—Magnetism should not be confused with electrical current. Magnetism is a property possessed by certain materials which causes that material to attract to it other materials. In certain cases the action is one of repelling rather than attracting. The earth iself is a huge magnet. Lines of force emanate at all angles from the magnetic north pole, passing north over the earth's surface at all points to the south magnetic pole where they re-enter the earth.

These lines of force are flowing at all points at all times and are readily detected by the magnetic needle.

Not all materials may be magnetized. Natural lodestones are found in certain localities and these exhibit the same characteristics as the bar or horse shoe magnets. Steel may be magnetized as may also iron. Brass, copper and aluminum are some of the non-magnetic metals.

Producing Magnetism. — Magnetism may be produced within steel or iron, or these metals may be said to become magnetized. Iron may be magnetized by the process of winding several coils of wire about it and sending a current of electricity from a battery through it. The magnet so produced will be found to attract bits of steel as nails, screws, iron filings, etc. Trying it with a box of nails it is found that a certain number of nails cling to the magnet directly while other nails cling to those attaching themselves to the magnet. Quite a group may be picked up in this manner. Breaking the electrical connection from the battery to the wire coil about the bar of steel will cause the nails to drop away, and a test will show that practically all of the magnetic strength of the bar is gone. In other words, since it no longer possesses magnetism it is not a magnet. If any, even a very little magnetism is left, it is because the bar is not pure soft iron but has some degree of hardness.

Residual Magnetism.—This is the amount of magnetism remaining in an iron core after the current is broken off. The softer the iron and more nearly free of foreign substances or alloys, the less residual magnetism is left after the core has been magnetized and the current broken. This type of magnet is called an electro-magnet because the magnetism is present only when the current is flowing. A good electro-magnet loses its magnetism immediately the current is broken.

Electro Magnets.—Electro-magnets may be in many forms such as the straight bar or the U bar, or the many forms of pole shoes used in electrical machines. In every case the electro-magnet is made by winding coils of wire around a piece of iron or steel which is the core of the magnet. The number of lines of force emanating from the magnet is directly dependent on the number of turns of wire and amperage passed through the coil. Much of the work done by electricity is dependent on the magnetic properties of steel and the laws of magnetism.

Magnetic Poles.—While with electrical current we have positive and negative terminals, with magnetism we have north and south poles. The magnetic North Pole is said to be some distance to one side of the geographical South Pole. Likewise with reference to the South Pole. In the case of magnetic poles, in iron or steel, like poles repel and unlike attract. If two magnets of like strength are brought

together they will repel each other, as two north poles or two south poles. If two magnetic poles, one a south pole and one a north pole, are brought close together they will swing together and cling tightly

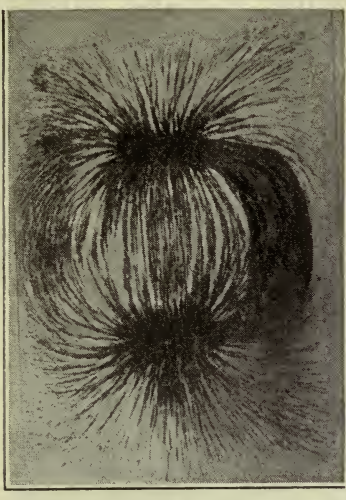


Fig. 269. Lines of force about ends of single magneto magnet.

Fig. 270. Double Magneto Magnets, like poles together.

Fig. 271. Single Magneto Magnet.

Fig. 272. Double Magneto Magnets, unlike poles together.

to each other unless some means is used to reverse the polarity of one or the other when the two will repel each other.

Magnetic Needle.—The magnetic needle works on the above principle. The needle itself is a magnetized steel bar, large or small. The

lines of force travelling over the earth's surface from south to north cause the needle to fall in line with them so that the point toward the north is the north pole of the needle, and vice versa. While the magnetic needle is made to serve the mariner or traveler through the compass, it may be made to serve the student or mechanic in indicating polarity of magnets for him. The same rule is operative in both cases.

Permanent Magnets.—The magnetic needle retains its magnetism indefinitely. This is because it is made from a high grade of steel

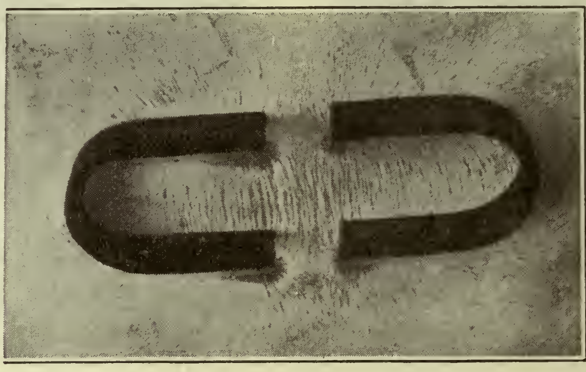


Fig. 273. Double Magneto Magnets. Like poles together.

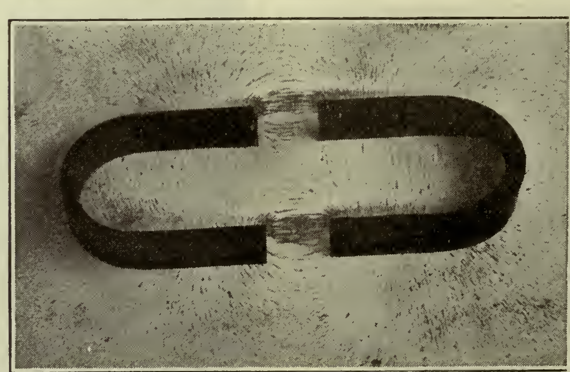


Fig. 274. Double Magneto Magnets. Unlike poles together.

hardened to a high degree of temper. Once a piece of hardened steel is magnetized it retains its magnetism as a permanent quality. It is thereafter called a permanent magnet. Lines of force flow continuously from its north pole to its south pole through the air or other medium. In a good magnet, well cared for, these lines of force seem to lose little strength from year to year, although they may be performing a great deal of work as in the case of the magneto magnets.

A number of illustrations, Fig. 269 to Fig. 276, show the flow of the magnetic lines of force. The student, in studying these, will want to remember that like poles repel, and unlike poles attract. All illustrations were made with iron filings sprinkled over a glass or directly onto the magnets.

Magnetizing Steel for Permanency. — In order to produce a permanent magnet it is necessary to have the steel first formed to the desired shape and then hardened. After hardening the usual method of magnetizing is to bring the ends into contact with a powerful electro-magnet. A permanent magnet may be used. The lines of force flowing through the body of the steel will cause certain changes to take place within the steel which result in the steel retaining its magnetism, thus making the commercial permanent magnet.

No. 275. Two stove bolts serve to deflect the flux in much the same manner as the armature core.

Fig. 276. Several bolts were placed between the pole shoes. Note how the center of the field is built up. The bolts serve the same purpose as the iron in the magneto armature. The flux follows the metallic path rather than the air gap.

The Molecular Theory.—The theory of the difference of the permanent and electro-magnets is one of the nature of the structure of iron. The molecules of iron or steel are similar. They may be said to have a certain slight freedom of motion within the soft iron, the softer the iron the greater the freedom of motion. On the other hand, the molecules of the steel have been fixed in position by the hardening process, having no power of themselves to move into position.

In magnetizing either metal the molecules drop into line with the lines of force because of the force of the magnetic action. In other words, the student may consider the infinitely small particle, the molecule, as having two ends. One end becomes a north pole and the other end a south pole. Now these molecules might be compared to the nails formerly mentioned. The north pole of one attracts

the south pole of another, and so on all the way through the magnet. All molecules being aligned with the axis of the magnet, all north poles point one way and all south poles of these molecules point the other way, until one end of the iron or steel bar is said to be a north pole and the other a south pole. Instantly, however, the outside influence is removed the molecules within the soft piece of steel fall back into a mixed position without any form or line of concerted action. Not so, however, with the hardened steel. These molecules are not free to move of themselves. The magnetic lines of force as applied changed their position and aligned them to form a magnet and they will retain the magnetism permanently simply because they

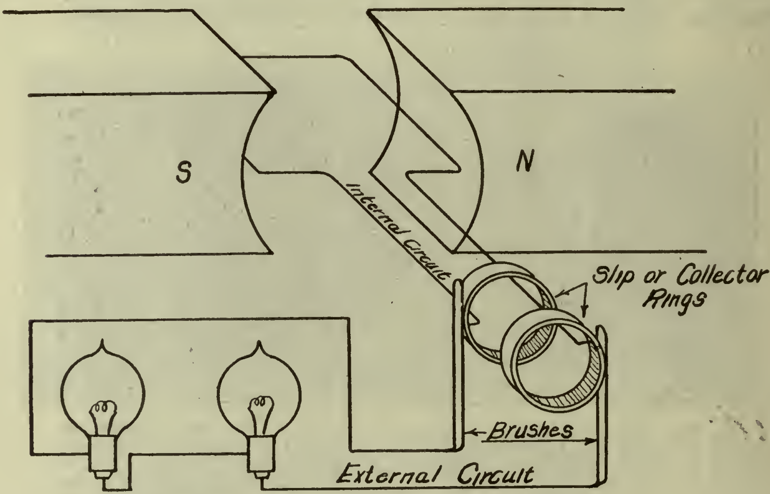


Fig. 277. Simple A. C. Motor or Generator.

must retain their position until disturbed by some outside influence. This theory is strengthened by the fact that when magnetizing a steel magnet, jarring it with a block of wood helps to increase the strength of the charge taken. Note also the fact that jarring a magnet in service will cause it to lose some of its strength. These facts would seem to indicate that the molecules being disarranged by the jar fall out of line and the strength of their bit of magnetism is lost to the magnet as a whole. The jarring or tapping seems to help the molecules in aligning themselves with the lines of force when charging and to help them fall back into their original position when not being charged.

Saturation.—Steel or iron always reaches a point where no more magnetism may be put into it. A sponge is completely saturated with water when no more water will be taken up by it. A magnet is completely saturated when no more lines of force will flow through

it because all are already flowing for which there is room. While this point is equally true of either type of magnet it has a peculiar application to the electromagnet. In this case the magnetism is induced by the current flowing through the wire wrapped on the core. A slight current gives slight magnetism, more current more magnetism, and so on until the saturation point is reached after which point an increase in current does not result in an increase in magnetism generally speaking.

Flux.—Magnetic flux or field is the condition of magnetism resulting between the poles of a generator or magneto where the lines

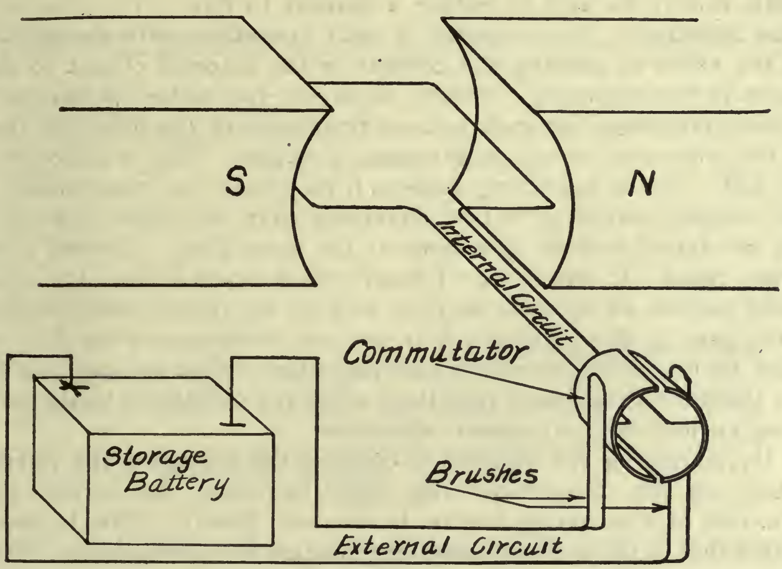


Fig. 278. Simple D. C. Motor or Generator.

of force are flowing. Magnetic lines of force constitute the magnetic flux, or flux as it is commonly called.

Current Generation.—The student has seen how the electric current may be used to produce magnetism where none existed before and will now be shown how the reverse may be accomplished. If a permanent magnet is so placed that a loop of wire may be mounted between the ends of it and caused to rotate on a central axis, it is made to cut the lines of force or the magnetic flux. Cutting these lines of force induces current in the wire. This current will flow from one end of the wire toward the other end of the wire and if slip rings and brushes are provided this current will flow from wire, to ring, to brush and off into an external circuit, from which point provision must be made to return it to the other slip ring and internal circuit. This internal current will continue to be generated as long

as the wire is in motion and an external circuit provided to handle it. Instead of two slip rings only one may be used. In this case the other end of the wire is grounded, as is also one end of the external circuit.

Internal Circuits.—The internal circuit is that formed by the wire on the armature, the rings, etc. The external circuit is that used to perform the work on the outside as lighting the lamps, charging the battery, etc.

Induction.—Whenever a loop of wire is made to cut magnetic flux it causes a current, or sets up a current within the wire. In other words, it may be said to induce a current to flow. The process is called induction. This reversal of ends in contact with the brushes has the effect of causing the current in the external circuit to flow always in one direction. Instead of having two pulses of current in different directions for each turn or revolution of the inductor, there are two pulses of current in the same direction. This is indicated in Fig. 279. To the beginning student it may seem an impossibility to have current traveling in two directions over the same wire but it does not travel in both directions at the same time. Current travel is very rapid. It would travel nearly eight times around the world in one second so reversal may be said to be almost instantaneous. In the case of direct current it is not one continuous even flow but might be compared to a series of pulsations following one another over the wire in the same direction, while the pulsations in the alternating current flow in opposite directions.

By increasing the number of coils on the armature, the number of bars on the commutator also being increased, the current flow while still of a pulsating nature, is far more steady. This is due to the fact that in the bi-polar armature there are two zero points. From these zero points to the peak of the pulsation and down again to zero as illustrated in Fig. 279, represents one-half revolution. In the next half revolution the same effect or result is secured. When many bars are used, it is only when the current is approximately at its peak that the brushes are in a position to take it off to the external circuit. Consequently the flow of current in the external circuit is at the approximate maximum pressure or voltage at all times.

Armatures.—The H or shuttle type of armature is the one where the slip rings are used resulting in an alternating current. By this is meant that it will flow first in one direction and then in the other through both circuits.

Alternating Current.—This is written and spoken of as A. C. current. As mentioned above, alternating current flows first in one direction and next in the reverse direction. When cutting the magnetic flux the inductor or coil is brought first into close proximity to the north and the south poles. In the next half revolution that

portion of the inductor close to the north pole is brought close to the south pole, and the part which was close to the south pole is likewise brought close to the north pole. This reversal of position of parts of the coil or inductor results in reversal of the direction of the flow of the induced current. There are two complete reversals of current within the wire each complete revolution as the armature is kept turning. A. C. current is quite suitable for certain classes of work, but is absolutely unsuited for other classes as, for instance, charging storage batteries. For those uses requiring direct current the generating machine must be so changed as to produce it.

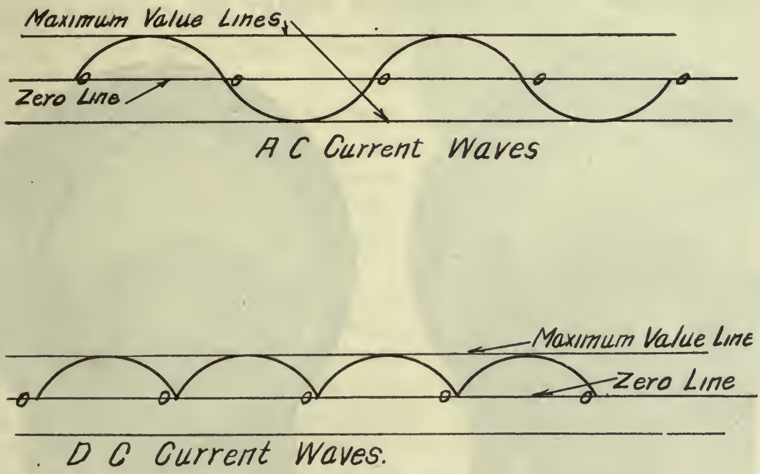


Fig. 279.

Direct Current.—This is written and spoken of as D. C. current. Current coming from batteries is always direct current. In order to generate it mechanically the slip rings must have a commutator substituted for them. In this case, as in the simple bi-polar machine with only one coil and two segments to the commutator, the separate ends of the coil are each brought to and soldered to the commutator segments. These segments or bars are separated from one another by some form of insulator. As the wire loop or coil is turned the end attached to any one of the segments is brought first into contact with one brush giving the pulsations from zero value to maximum value each half turn. This is equipped either with slip rings for A. C. current or with an armature for D. C. current. The invention of the drum type armature has made possible the steady flow of current described in the preceding paragraph. Illustrations of both the shuttle or H type as well as the drum type are shown in Fig. 266. The student will be interested to know in what machines each is used. This information will appear at a later point.

In actual generator or magneto work a coil of many turns is substituted for the single loop shown. This coil is wound on a soft iron core, the whole being mounted on a shaft in its center, on which it is revolved. Either one or two slip rings are used while for the D. C. current a commutator is substituted. In the drum armature a number of coils are used.

As stated previously the voltage depends on the number of lines of force being cut, and the rapidity with which they are cut. For higher voltage the speed of the armature must be increased or the number of turns of wire increased.

Commutator. — The commutator usually has as many bars as

Fig. 280. Voltmeter.

Fig. 281. Ammeter.

there are coils on the armature, although at times two coils will be attached to the same segment. The segments or commutator bars are insulated from each other. For this purpose mica is the standard material. It is a very high class non-conductor. Commutators and slip rings being subjected to wear require some attention. The matter of their care and repair is treated at a later point.

Field.—That part of an electric machine which has the essential parts so arranged as to produce and maintain a magnetic flux for the armature to revolve in is called the field or fields. Usually the field is stationary, but may be in motion. In the case of the magnetos the permanent magnets with their everflowing lines of force are made use of in building up the field. In the case of generators the electro-magnets constitute the field. The wires or conductors are called the field windings. The field windings in modern practice are mounted

on the poles themselves although at times they may be found on the yokes of the field castings.

Current Control.—External control of the amount of current flowing may be had similar to the control of other sources of power. A large steam pipe is needed to carry steam from the boiler to the locomotive cylinders. A smaller pipe is needed for the smaller engine. The pressure per inch may be the same in either case, but the amount of steam flowing through the smaller pipe is less than that flowing in the larger pipe. The same is true of the amount of work done.

Fig. 282. Voltammeter, a combination instrument for measuring either volts or amperes.

Similarly in the case of the current flowing from a battery. The larger the conductor and demand the more the amount of current which will flow. The smaller the conductor the less the amount of current which will flow no matter how great the demand. Accordingly a large heavy cable is used to connect the starting motor which may draw up to 300 amperes momentarily while starting the engine to turning. The voltage or pressure can be no more than that of the battery, in most cases six or twelve volts. For lighting and ignition very light cables are used as the current consumption is seldom over six to eight amperes. Necessarily the voltage is the same as for the work consuming the greater amount. However, even these lighter wires or lighting cables would carry a great amount of current if there were not provision for cutting it down. Within the lamp bulb the filament is heated because of its natural resistance to the flow of current. The student is, of course, familiar with the fact that the filament is ordinarily mounted in a vaccum, or that there is no air in the bulb. In the case of the nitrogen bulb it is filled with nitrogen gas. However, in either type the filament is heated by its resistance to the passage of current until the bulb is made to glow brightly. At the same time, however, only a certain amount of current or amperage can pass through the filament. If more light is desired, more filament is added. This necessarily requires more current to light it or heat it to an incandescent heat. Larger candle power bulbs always impose a heavier drain on the storage battery. This is just the same as the large steam cylinder which uses more steam than that on the engine having less power and less size to the cylinder.

Resistance Units.—While the lamp bulbs might be said to be resistance units serving to regulate their own current consumption through their size, other units of automotive equipment are supplied with separate and individual resistance units. It has been explained previously that all metals are conductors of electricity. Platinum, silver, and copper are the best conductors. Iron is only about one-seventh as efficient as copper. Certain other metals are even much poorer. Some of these composed largely of nickel, michrome, or German silver are sold under the trade name of resistance wire,

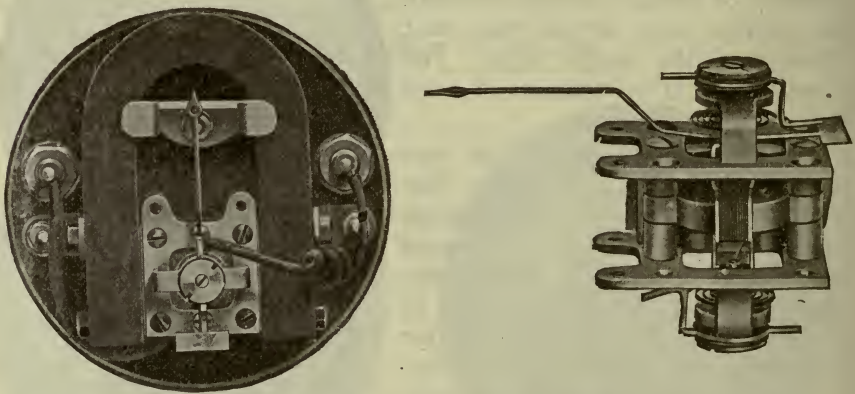


Fig. 283. Internal mechanism of Electrical Measuring Instrument, as voltmeter or ammeter.

because of their remarkable resistance to the passage of electric current.

Ignition units or coils are usually provided with a resistance unit or coil which protects the coil winding from excessive amperage and consequent damage. It serves to regulate the amount of current flowing in such manner that the spark produced is approximately the same for all engine speeds.

A quality of resistance wire to be remembered is that the resist-

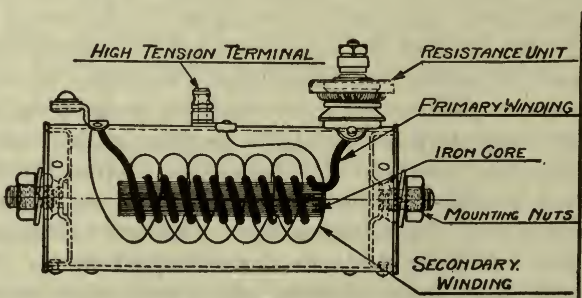


Fig. 284. Resistance Unit on Coil.

ance to the passage of current increases with the amount flowing. The student has noted in the case of the lamp bulb that it is resistance which causes the filament to be heated and glow. In the case of the resistance unit this is also true. A continuous flow of current will heat the resistance unit. As it heats, its resistance increases. The hotter the wire, the greater the resistance. This causes the cutting off of the flow of current at least partially, and this in turn allows the resistance wire to cool a bit when more current starts flowing again. It is a safety valve or governor for the coil. This feature prevents the ignition coil being burned up when the ignition switch is left on and the engine standing still with contact points together.

Fuses.—The student is now familiar with the fact that electricity flowing through a conductor is likely to heat the conductor. The amount of heat developed is dependent on the amount of current flowing, as well as the size of the conductor. It may even heat the conductor or wire to a point where the insulation will be burned off, or in extreme cases melt the conductor.

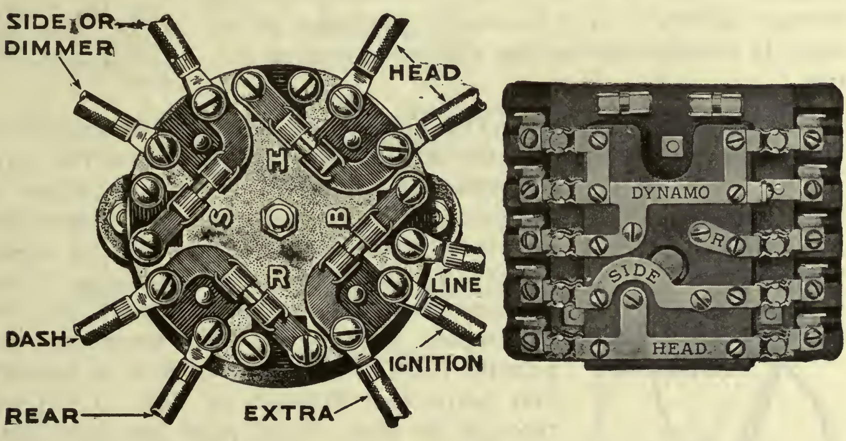


Fig. 285. Switches with Fuses mounted on the back.

To prevent damage to expensive units of equipment practically all systems are equipped with fuses. The fuse is a protector. If an excessive amount of current flows the fuse is burned out or melted out. Fuses are made from metal with a low melting point. They are designed to form the weakest point of the electrical circuit so that there will be no doubt about which part will be burned out first. When a fuse burns out it opens the circuit just as the opening of a switch would. Thus, a unit costing a few pennies is made to protect one costing many dollars. Needless to say, a burned fuse should be replaced with another of like capacity. Metals which cannot be burned

out should never be substituted, neither should very much heavier fuses be used. The trouble causing the fuses to burn out should be located and corrected before replacing the fuse.

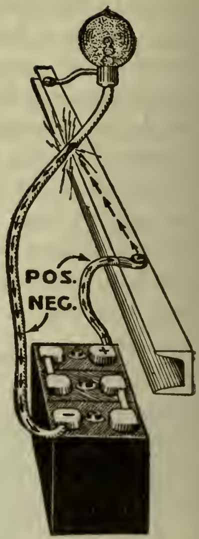


Fig. 286. Short circuit. Note also method of grounding battery to car frame.

Ground.—Presumably from the fact that the earth or ground is used for return circuits in many cases of electrical installation, or for the protection of others from over-charge, has come the practice of terming the frame or superstructure of the automobile the ground. Automotively speaking, to ground a circuit is to attach one end of the wire forming the circuit to the frame or other metal part of the car, allowing the frame to act as the return circuit. A magneto may have one end of the primary winding or internal circuit grounded through the bearings; similarly the generator. The high tension or secondary current as used in the spark plugs is always grounded. One terminal from the storage battery is very frequently grounded giving what is constituted the one wire or grounded system.

Terminals and Poles.—The polarity of a magnet is dependent always on the direction of the flow of the current around the core. Reversing the direction of flow of current in the case of an electro-magnet will reverse the polarity of the magnet. If no magnetic needle is at hand to determine the polarity of the magnets, that of the electromagnet may be determined as follows: To determine the polarity from the direction of flow of current, first learn the direction of flow of current through the wire. Next, place the right hand so that the fingers point in the direction of the flow of current. The palm of the hand would be next to the coil. The thumb pointing at right angles to the hand will point to the north pole.

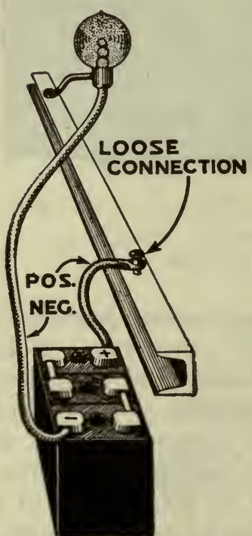


Fig. 287. Open Circuit due to Loose Connection.

Direction of Induced Current.—To determine the direction of the flow of an induced current as generated in a magneto or generator, or the positive and negative terminals of the conductor in which current is induced, it is necessary first to determine the polarity and direction of lines of force or the magnetic flux. Knowing this, set the thumb of the right ıd to point in this direc-

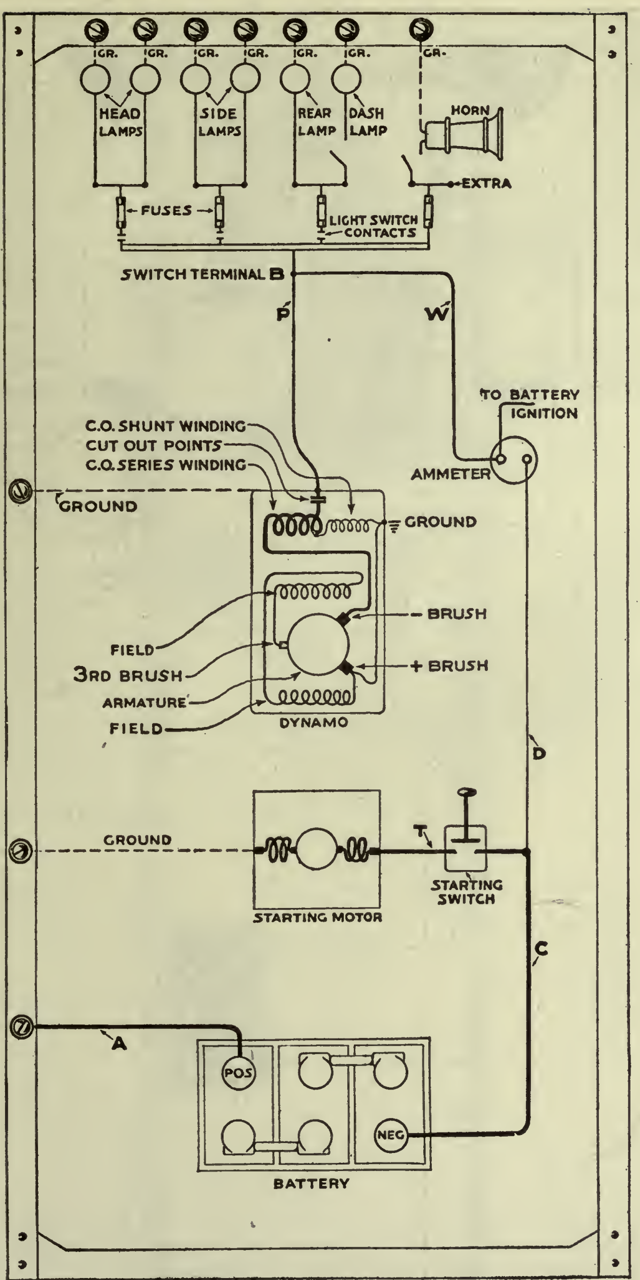


Fig. 288. Technical Wiring Diagram.

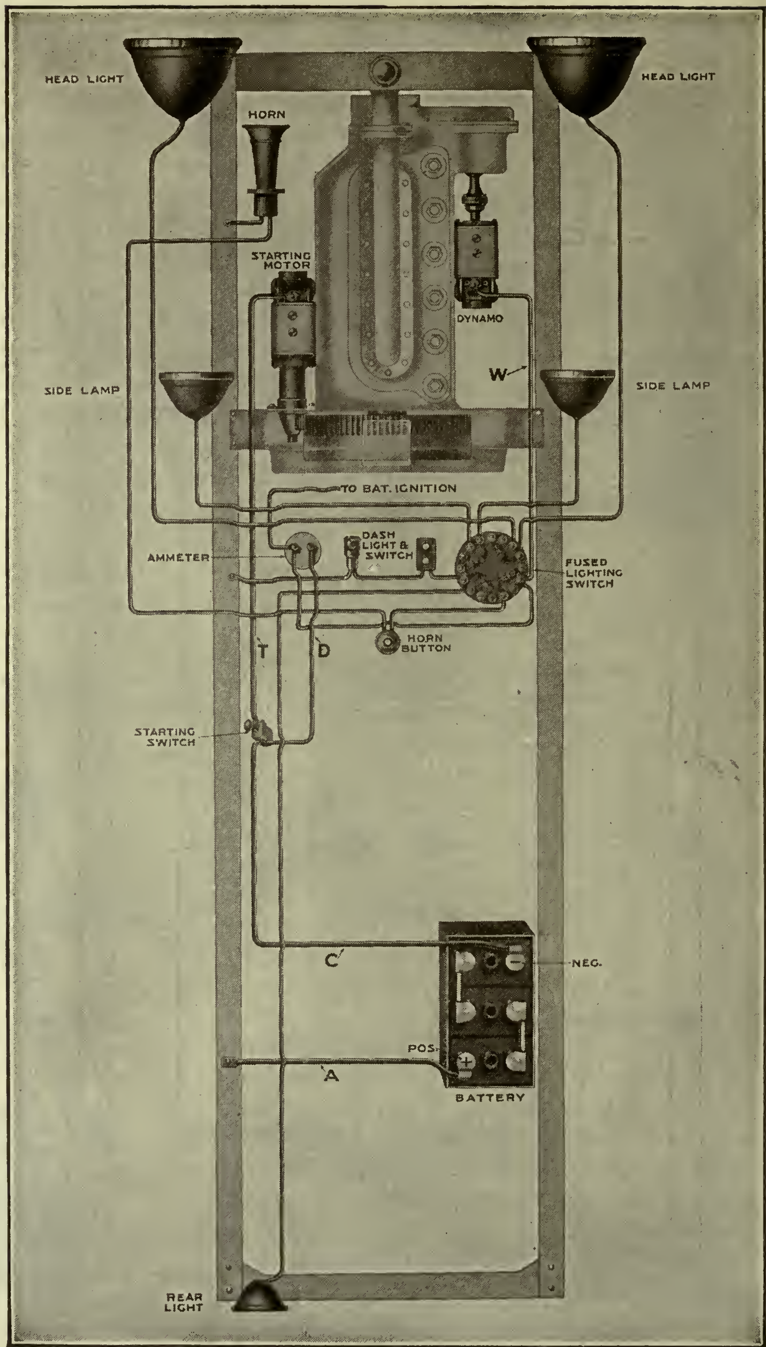


Fig. 289. General Wiring Diagram.

tion. It should also be at right angles to the index finger. Next set the second finger at right angles to the palm of the hand, and pointing in the direction of the conductor travel as it cuts the lines of force. The index finger pointing straight indicates the direction the induced current will flow.

Solenoid.—A solenoid is a coil or a helix of wire. It might be said to be an electromagnet without an iron center or core. It has the general characteristics of an electromagnet although the pull will naturally be less. The magnetic poles north and south are in evidence. The south pole will be that in which the current flows in a clockwise fashion when the observer is facing it. The same rule applies to electromagnets.

Condenser.—It has been learned that it is possible to store up a charge of electricity which may then be drawn off for use in performing work. The storage battery is a device used for this. The condenser is likewise a device used for storing current, but in the case of the condenser there is no chemical action and in most cases the charge is held only momentarily.

The condenser is made up of paraffined paper and tinfoil. The paper is laid between the layers of tinfoil and the whole wound into convenient form and pressed into the desired shape. This form or shape depends on the housing designed for the condenser.

The capacity of the condenser depends on the number of square inches of the surface of the dielectric which is the paraffined paper. The tinfoil serves to conduct the current to and distribute it over the surface of the dielectric where it is held.

The condenser is used in the ignition coil circuit. Its action is described further at a later point.

CHAPTER 11

BATTERIES AND BATTERY CARE

As indicated in the previous chapter, the storage battery can generate little or no electrical current or energy without first being subjected to a charge from an outside source. It might be compared to a tank for storing compressed air. A stream of air under pressure is forced into the tank until the gauge registers, say 100 pounds per square inch. This air may be drawn off through an air line for use in inflating tires. After one tire has been inflated, there is less pressure registered on the gauge. After two tires are inflated, less again, and after three tires still less, and so on. Very shortly, unless the compressor is started to work and the tank refilled, the pressure will be too low to inflate any more tires properly.

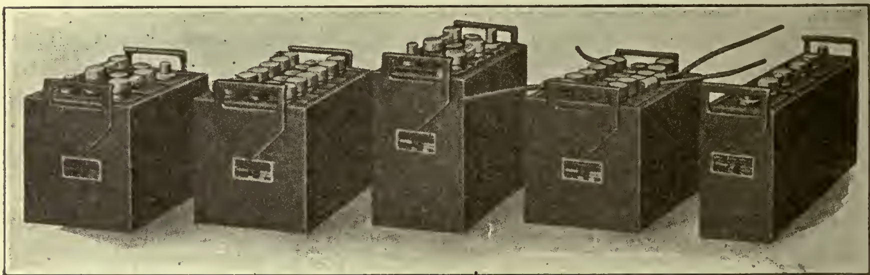


Fig. 290. A group of Starting and Lighting Batteries. (Cincinnati.)

The case of the battery is very similar. If the starter is used frequently the battery will quickly become exhausted. However electricity is not stored in the battery as air is stored in the tank. The same air which is run into the tank is later drawn out to inflate the tires. In the case of the battery being charged the current flowing through the battery drives the acid from the plates into the solution. When the external circuit of the battery is closed the battery is said to discharge. That is, current is now flowing from the battery to the starter, ignition, or lights. This current being taken out is not the same as went into the battery when it was charged. In charging a battery the current flowing into it sets up certain chemical action. When the external circuit is closed the current flowing from the battery is due to the reaction within the cells.

Battery Rating.—While storage batteries are rated by ampere hour capacity when on discharge, we find that automobile starting and lighting batteries are given the capacity rating when discharged at the five ampere rate. Therefore, a battery discharged at the rate

of five amperes for twenty hours would have a capacity of 100 ampere hours. As the rate of discharge is increased the ampere hour capacity is lessened, or as the rate is decreased the ampere hour capacity will be increased. For example:

The 100 ampere battery at the five ampere rate would have a capacity of only about 80 ampere hours when discharged at ten amperes, or in other words, it would discharge at ten amperes for eight hours. If the same battery were discharged at one ampere it would give off current for about 120 hours, therefore having a rate of 120 ampere hours. It will be seen that the battery could be completely discharged in a very short time if the discharge rate were

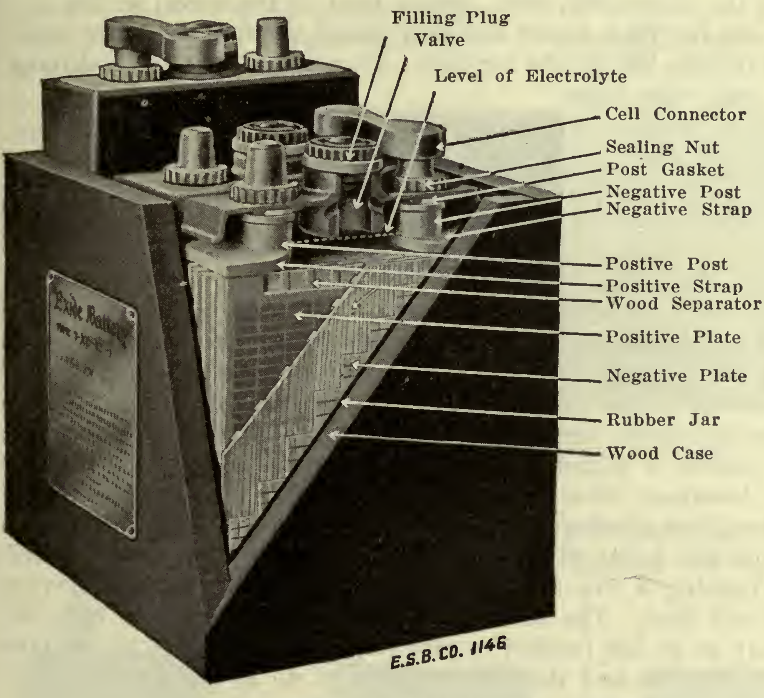


Fig. 291. Battery Cut Away to Show Construction.

200 to 300 amperes as is the case in cranking the motor with the battery. In fact the discharge rate runs even higher under particularly unfavorable starting conditions. Every second the starting motor is running means great drain on the battery.

The student will note likewise the fact that the slow, steady, continuous drain as that of the lights burning with the engine idle, or ignition switch left on will deplete the battery. Automotive engineers have designed the generator as part of the electric system. Its duty is to send the current through the storage battery and cause such

electro-chemical action there that the battery is always ready to give off energy in the form of electric current.

Battery Wear.—One of the greatest problems meeting the battery manufacturers is that of educating the users of automobiles and other electric equipment with reference to the storage battery. An air tank may be charged and discharged many times a day and over a space of many years without showing signs of depreciation. Not so with the battery. Each charge and discharge produces wear within the battery. The vibration to which the battery is subjected contributes to wear. This is natural wear but serves nevertheless to shorten the life of the battery. In this respect the battery might be compared to the automobile tire. Every turn of the wheel as the tire travels over the road means one turn nearer the final one. So much service has been had by the car user. Of course, the user, by driving

Fig. 292. Storage Battery Name Plate.

carefully and keeping proper air pressure in the tire, will get many miles of service from the tire. The miles of service bear a very direct relation to the amount of care and the pressure carried. Just so in the case of the battery. It must be kept fully charged so as to have a reserve to withstand the demands made upon it for current. Careless handling, failure to provide the proper amount of distilled water, complete discharge, failure to bring to a state of complete charge and like faults will as certainly limit the service a battery will give as running a tire flat, or under-inflated, will limit the service the tire will give. The user of the battery must learn to care for his battery as he has learned to care for his tires. There are certain things he may do and should be taught to do by the battery man. Then, when the battery has served its life-time, it will be easier for the battery service station to deal with the user. He will understand that the battery is not like a piece of steel to which there is no wear, but rather like the tire it returns service for understanding care.

BATTERY CONSTRUCTION

Battery Box.—The battery box is carefully made from good wood. It is designed of such size that the cells will just fit into it with room for proper sealing. Handles are attached in such manner that there is no danger of the screws or bolts coming into contact

with the jars, in a manner likely to break them. The bottom of the box, in some instances, is provided with an expansion joint to care for the natural expansion and contraction of the wood. It also serves the additional purpose of allowing any moisture such as might come from spilled water or electrolyte getting down between the cells as is possible in certain types of assembling. The box is always covered with acid resisting paint to protect it from attacks of the acid in the electrolyte.

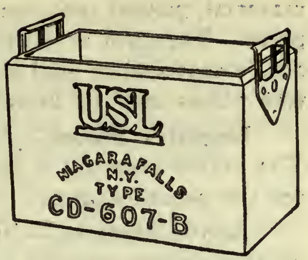


Fig. 293. Battery Box.

Cell Jars.—For automotive equipment the cells are always made of a specially prepared hard rubber. This is an insulating material and at the same time will stand some slight strain without breaking. The cells vary in size, being designed to just receive the element when it is fully assembled. No appreciable movement of the element within the cell is permissible because of the rapid depreciation and wear which would occur. The bottom of the cell has ribs moulded across it for the plates to rest on. The space below the tops of these ribs receives the sediment from the plates as it is worn from them.

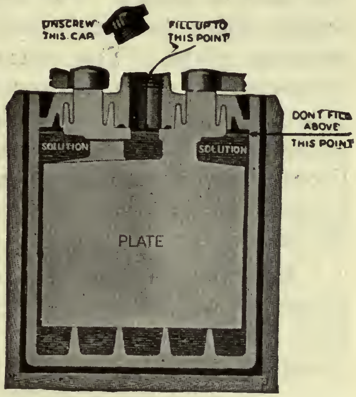


Fig. 294. Battery Section. Note Cell Jar Construction. (Willard.)

Element.—There are always two groups of plates in each cell. These are insulated from each other by means of the separators.

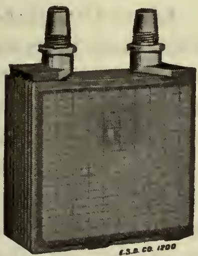


Fig. 295. Complete Element. (Exide.)

Fig. 296. Positive Plate.

Fig. 297. Negative Plate.

One group of plates is called the positive and the other is called the negative. When properly assembled and insulated with the separators the entire assembly is called an element.

Positive Plates.—All plates are built up of socalled active

material, pasted into the grid which is the frame or backbone of the plate. The grid is made from a stiff lead and is so molded that the active material is held in between light bars of the metal. The positive plates may be known by their chocolate color.

Negative Plates.—These are known by their slatish gray color. The active material is pasted into the same type of grid as that used for the positive ones.

Active Material.—In order to insure the rapid and ready action of the active material pasted into the plate grids, it is made up of lead oxides mixed with certain other materials. Red lead is mixed with certain other materials and electrolyte to form the paste for the positive plates. The litharge, another lead oxide, is mixed with certain other materials and electrolyte to form the paste for the negative plates. The exact composition of the materials and the proportion of each kind used are trade secrets which are carefully guarded. Not all companies use the same formula, nor are the methods of handling the plates in forming the same in all cases. From long experimentation each company has arrived at the best formula for its own purpose and that best suited to its method of manufacture.

Forming Plates.—As suggested above the methods of forming plates are not the same in every instance. All green plates are carefully dried before forming. The forming is the final process of plate manufacture.

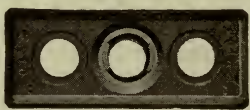


Fig. 298. Cell Jar Cover.

One method of forming plates is as follows: After the plates are pasted and dried, they are placed in tanks, positive and negative plates alternately, there being usually about 80 plates per tank. All positive plates in each tank are connected, while all negative plates are similarly connected. The negative plates of one tank are then connected to the positive plates of an adjoining tank, there being only enough tanks in the circuit so that the voltage from the plates will not exceed the voltage of the charging circuit. The tanks are filled with a low density of electrolyte which covers the plates, allowing the current to pass from plate to plate during the forming process.

Another method of forming the plates is as follows: After the plates are pasted and dry they are assembled in groups by lead burning, just as they are to be used in the battery. Next, the positive group is assembled with a dummy negative group, with separators between, and set into a cell. When the cell has been filled with

1250 electrolyte the positive group is connected to the positive lead from the charging circuit and a current sent through the element. This forms the positive plates in approximately 48 hours. The negative group is assembled with a positive dummy and formed in the same manner excepting the time required which is 72 hours.

After the forming process is completed the positive plates, due to the electro-chemical action, are lead peroxide, while the negative plates are sponge lead. In the forming process, it is necessary that the plates which are to be formed into positive plates be connected to the positive lead of the charging source.

This is a point of vital significance in the charging of a battery. If the battery is put on the line with the negative terminal connected to the positive lead of the charging equipment, the battery plates will have to be reformed before the battery will take a charge. The change is certain to result in disaster and too much emphasis cannot be laid on the matter of putting the battery on charge correctly. Methods of determining polarity are given elsewhere in this chapter.

Separators.—The separators are made from some insulating material such as specially prepared rubber or wood. The latter material is the most popular with manufacturers, inasmuch as it is the cheapest and most easily handled. However, it does not always give the longest service. Where wood is used the acetic acid is removed to render the separator impervious to the attacks of the electrolyte. This special treatment also leaves the separator porous which is essential to all separators, as it allows the passage of the electrolyte. The separators must be insulating material, otherwise short circuits would be developed immediately within the battery and it would be impossible to charge it. Whenever the insulators wear out or break down, the battery will develop short circuits which prevent it taking a charge. The average life of a set of wood insulators or separators is about one year. Some will give less than this amount of service and in many cases more. Unusual cases of three and four years are on record. The rubber insulators and separators such as the Willard Threaded Rubber as a rule give considerably more service. Here again the battery might be compared to the tire. A fabric tire, while well worth while, will not as a rule give as much service as the cord tire. This does not mean the fabric tire is not worth the money invested in it but does mean that the greater

Fig. 299.
Wood Separator.

Fig. 300. Wood Separators, worn out by overheating, undercharge or overcharge.

amount of money invested in the cord can be expected to make a greater return to the user, in the amount of service.

Cell Covers—One of the hardest problems the battery manufacturers have had to solve is that of properly securing the element in the cell and sealing the top of the cell so that the electrolyte is not spilled out when the battery is in service. The hard rubber cover is designed to care for both the holding of the element in position and sealing the top of the cell. It also has the filler cap or vent plug fitted into it. Holes are molded into it, so placed that the posts will come up through them and permit of the terminals and straps being burned on above the cover. The cover is designed always with the idea of perfect sealing in mind. Various methods are used by the manufacturers, and the student will need to understand something of this construction before attempting to dismantle any particular style.

Sealing Compound.—The sealing compound is a tar or pitch-like preparation which is heated in a pot or dipper until it is melted, when it may be poured around the cell covers to seal the jar and cover together. It is also used in certain types to seal the posts and to seal the cells into the box thus preventing any moisture getting between the jars, as well as shaking about of the cell jars in the case or battery box. The sealing compound may be purchased from the supply houses. Directions for its use appear at a later point in this chapter.

Fig. 301.
Standard Thimble
Type Terminal.

Fig. 302.
Standard Taper
Plugs and
Screw.

Fig. 303.
Straight Clamp
Lug Terminal.

Terminals and Straps.—There is some difference in the style of terminal used by the battery manufacturers and car builders. The corrosive effects of acid make it necessary to lead coat all brass

Fig. 304.
Cell Connector.

parts or make the entire terminal from lead alloy. Figs. 301 to 303 show some of the most popular forms in use. The prime requisite

in their use is cleanliness which is best secured through the use of a baking soda solution used to clean them and neutralize the acid. This prevents the terminals from being constantly enlarged as is the case where a knife blade is used to scrape them clean. Do not allow any of the cleaning solution to get into the cells. Fine sandpaper is often used to advantage. When properly cleaned a thin coat of vaseline or light cup grease will serve to protect them.

The straps or connectors are used to join the negative post of one cell to the positive post of another cell. These, like the terminals, are usually attached by burning them to the posts.

BATTERY CARE

As suggested previously proper care of the battery is essential to service. Even with proper care there is a limit to the normal life of the battery. Neglect of the two fundamentals, a proper charge and the addition of distilled water always materially limits the life of the battery.

Distilled Water.—Every storage battery is dependent on the electrolyte surrounding the plates for its electro-chemical action. Electrolyte is made up of two elements or liquids, water and sulphuric acid. The acid is not subject to evaporation. The water is. This accounts for the fact that acid does not need to be added to a battery to bring the solution up to the proper level, while it is necessary to add water at regular intervals.

Only pure or distilled water should be added to the solution since water bearing any impurities will introduce them into the battery where, due to the chemical action, they may do serious harm. Metal vessels or containers should not be used for the distilled water. Instead, glass or glazed earthenware should be used. It may be secured from the supply houses or drug stores. In adding distilled water the plates within the cell should be covered to approximately one-half inch above their tops. The electrolyte should not be permitted to drop below the top of the plates at any time. Water added to a battery remains separated only so long as it may be necessary for the motion of the car and the charging action of the generator current to mix it with the electrolyte. For this reason some care must be used in adding the water in the winter time. In this case it should be added just before the car is to be operated so that the water and electrolyte may be thoroughly mixed. In case of any water being spilled on the battery top it should be dried with a cloth. To prevent spilling when filling use a syringe or glass funnel. It frequently happens that a battery which has been filled carelessly will become discharged without apparent reason. This is due to the fact that the spilled water and electrolyte have established a short circuit through which the battery discharges as fast as the generator charges it.

Battery Freezing.—This is not likely to happen even in extreme temperatures if the battery is properly charged. Sulphuric acid will not freeze. Water will freeze. By keeping the two mixed in the form of electrolyte the water will not freeze. As stated previously, however, when the battery is discharged the acid has practically all

Fig. 305. Hydrometer.

entered into the plates. This leaves only the water surrounding them, consequently the reason for a discharged battery freezing is evident. Bringing the battery to a full charge will drive the acid out of the plates into the water again, thus bringing the electrolyte up to its proper strength. The specific gravity of a fully charged

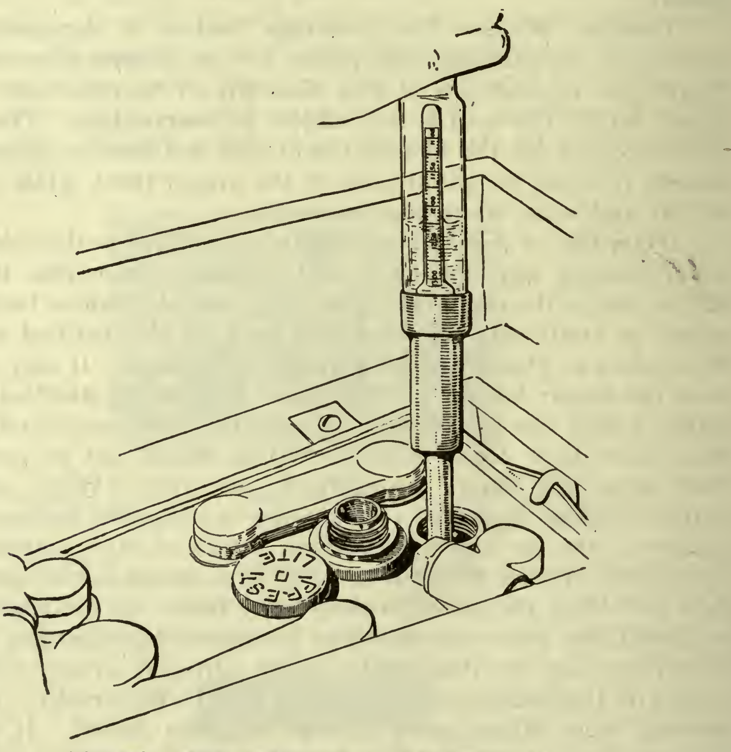


Fig. 306. Using Hydrometer to Test Battery.

battery will read between 1.275 and 1.300. At this point it will not freeze except at extremely low temperatures as approximately 80

degrees below zero. On the other hand a fully discharged battery will freeze at zero or above. Hence the necessity of keeping well charged during the cold winter.

Testing Battery.—The reliable test to use in judging the state of charge of a battery is the hydrometer test. Just as the scales will show that a piece of lead will weigh more than the same size of a piece of aluminum and not only that, but the exact difference in weight, so the hydrometer will show the weights of liquids. Water is taken as the standard fluid and all other liquids are judged as they are heavier or lighter than it. For the sake of a starting point water is said to have a specific gravity of 1.000. Sulphuric acid is almost twice as heavy having a specific gravity of 1.835.

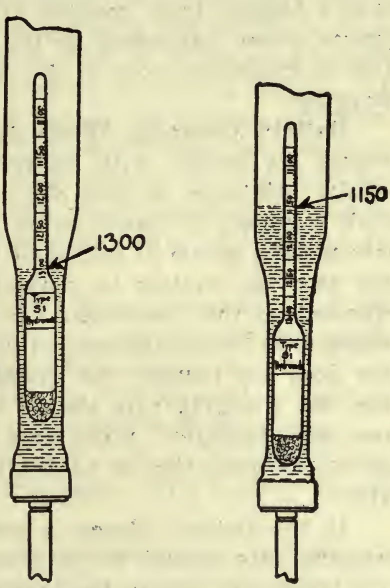


Fig. 307. Hydrometer Readings for fully charged (1300) and discharged (1150)

Hydrometer Reading.—With a little practice the hydrometer is readily used and properly read. In taking the specific gravity of the battery it is placed with the rubber tube end in the electrolyte having first deflated the bulb. Next carefully release the pressure on the bulb and the electrolyte will be drawn up into the body of the instrument. In this portion of the instrument is placed the hydrometer proper, the other parts really being a syringe arrangement. With the electrolyte in the body of the syringe the hydrometer will float. The more nearly the battery is to a full charge the higher the hydrometer will float. The graduations are read at the upper level of the electrolyte. To do this properly it is necessary to bring the level of the eye even with the level of the liquid within the hydrometer. It is also necessary to see that the hydrometer is actually floating, without the top touching the upper end of the chamber or the bottom resting on the bottom of the chamber in which it is contained. After the electrolyte has been drawn into the instrument to the proper level to float the hydrometer nicely, a little pressure should always be given the bulb to relieve any vacuum in the upper part of the chamber, otherwise the reading will be too high.

On the hydrometer, or within it, appear the graduations which are used to indicate the state of charge. These graduations usually run from 1.150 to 1.300. The first figure indicates complete exhaus-

tion or discharge. The second figure means that the battery is fully charged if the hydrometer is carried by the electrolyte with this point even with the surface. It is the practice of the hydrometer manufacturers to mark the instrument for the vital points.

A gravity reading of 1.150 indicates fully discharged.

A gravity reading of 1.220 indicates half charged.

A gravity reading of 1.280 indicates fully charged.

The student will understand, as he becomes familiar with batteries and methods of judging their condition, that it is possible to have a battery fully charged at readings either above or below the figures given depending on the original strength of the electrolyte. This is explained fully in the following paragraph covering battery charging.

Battery Charging While in Service.—The owner should either inspect his battery with reference to water and state of charge at regular intervals, or take the car to the service station where the work is generally done free of charge. If the battery is maintained between the points of 1.250 and 1.275 by the generator it is an indication that the system is properly adjusted for the type of service expected of that particular car. If the battery shows a continued tendency to become exhausted it should be given a special charge. If this does not remedy the trouble and the battery is in good condition, the charging rate should be adjusted to give a higher output from the generator. Care must be used not to exceed the rated output of the generator or to injure the battery by an excessive charge rate.

If the battery shows a tendency to become overcharged the charging rate should be lowered, or if the trouble is thought to be of a temporary nature the lamps may be burned in the day time or while the car is housed in the garage over night to reduce the charge and the specific gravity. The same result may be obtained more quickly by operating the starting motor for a short time, say from three to eight minutes. The slower discharge is the better. For summer touring extreme care must be used to prevent overcharging and breaking down the battery due to overheating. Overheating causes the plates to become buckled and the active material to become loosened from the grid.

Again the battery may be compared to the pneumatic tire in that the hydrometer shows the amount of current in the battery as the tire gauge shows the amount of air in the tire. Using a battery when it is nearly exhausted is just as bad as running a tire with very low pressure over a rough street. Putting an excessive amount of air into a tire is very likely to produce disastrous results. When the tire blows out it may be beyond repair. Overcharging a battery is likely to do the same for it. When it finally fails it is ruined beyond repair.

HOW TO RECOGNIZE BATTERY FAULTS AND GOOD AND DAMAGED BATTERY PARTS

As indicated previously, natural wear and usage limit the life of the battery. Abnormal usage makes the life of the battery very short in many cases. How to detect incipient cases of trouble and correct them was mentioned in the previous section of this chapter. To detect and remedy the more serious cases of trouble is the work of the battery service station. In most cases this means the opening of the cells to permit of visual inspection of the plates and separators.

Tests Which Indicate the Need of Opening the Battery.—If a battery refuses to take a charge or runs down in a short time after having been charged the indications are those of internal trouble. If the battery runs down quickly when in position on the car, but holds a charge when charged separately and left off the car, the trouble is likely with the external car circuit which should be inspected for grounded or short circuited leads. Tests for determining trouble in the starting, lighting and ignition circuits are given in Chapters 12 to 15.

If, however, the battery will not hold a charge even when off the car no more time should be lost before it is opened and inspected. Inspection will show whether it is advisable to repair or not.

If a battery is known to have been frozen it is advisable to open it.

If a battery has been overheated it is advisable to open it up.

If the electrolyte shows red or muddy it is an indication that the active element is dropping from the grids. The battery should be opened for inspection.

If the battery has one or two cells which are always lower in point of gravity reading and water level it is an indication that the cell jar is leaking. If, however, the cell which always has the low solution level shows the highest gravity reading, it is possible that the heat of the higher charge is evaporating more water from it than from the others.

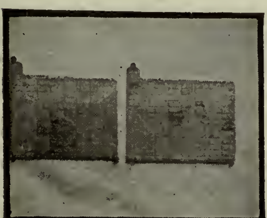


Fig. 308. Negative Plates Sulphated from too low a level of Electrolyte.

If the crack in the jar is large the loss of electrolyte is evident from the fact that the battery box and container are wet, as well as the fact that the electrolyte cannot be maintained at the proper level.

The methods of opening batteries are described at a later point. Before proceeding with that and actual repair methods, the student should know how to recognize plate condition and value.

Sulphation.—In the mind of the novice the term sulphation means a condition which is certain to ruin the

battery. This is not always the case, by any means, since the normal action of the battery is dependent on sulphation. When a battery is discharged, or rather when the chemical action within the battery, which is responsible for the flow of surrent from the battery, is going on, the sulphuric acid or sulphur within the electrolyte is leaving it and entering the plates causing sulphation. When the battery is charging, the sulphuric acid is being driven out of the plates leaving the positive plates lead peroxide, and the negative plates sponge lead. The current production of the battery is dependent on normal sulphation.

Lack of a full or proper charge allows the plates to sulphate abnormally or to an excess degree. When this condition obtains the plates become coated with a grayish substance, which covers the surface sealing the pores, thus destroying in part the activity of the cell. This is evident if a voltage reading is taken. In a badly sulphated cell the voltage drops off very materially. A cell or battery which has been left for some time in a badly sulphated condition, which is the case in partially or wholly discharged batteries, is very difficult to charge. The acid in the plates has sealed them and it is hard for the electric current to drive it out in charging.

Sulphation may be due to a low electrolyte level which has permitted the upper part of the plates to stand above the solution as well as to the lack of proper charge. Fig. 308 shows sulphation due to too low a solution level.

Fig. 309. Warped Plates.

Overheated Plates. — Charging a badly sulphated battery at other than a very low rate is practically certain to cause the plates to buckle and warp. In some cases the force is sufficient to break the cell jars and loosen the covers. This is due to the rapid and unequal expansion of the active element. Unless sufficient time is given for the strains to be neutralized within the active material itself warping is certain to result. Fig. 309 shows a group of warped plates.

Damaged Separators.—It is seldom, if ever, advisable to use old wood separators the second time. It is far better to replace them with new ones inasmuch as a cheap unit is made to protect the plates which are the expensive parts of a battery. In the case of separators such as the Willard Threaded Rubber and certain other ones, it is possible to use them as long as they are not damaged in any way such as being cracked or torn, or if they are not worn through from use between the plates. As stated before, the separator must be an insulator as well. If all or part of a separator is missing from its position between the plates there is certain to be a short circuit

developed at that point. It is just as though two wires carrying current were permitted to touch each other. Fig. 300 shows the effect of wear and usage on wood separators.

Frozen Plates.—The plates from a battery which has been badly frozen are readily recognized by the fact that there is little left but the grids. The active material falls from the positive plates in chunks. In other words, the active material with which the grids were pasted is all falling or has fallen out of them. In this respect it resembles the plate which has been subjected to continuous overheating and overcharging. The overheated plate disintegrates a bit more naturally than the frozen one. Knowledge of conditions of service will help the student to differentiate between the two.

Fig. 310. Testing a Positive Plate.

Judging the Value of Positive Plates.—If the active material is practically all in place and seems fairly hard when tested with the blade of a knife, Fig. 310, the plate will give enough additional service to warrant the expense of reinsulating and reassembling. However, if the active material is loose and considerable of the surface gone it is best not to use it.

Judging the Value of Negative Plates.—Negative plates very seldom wear out before the positive group. Sulphation is more

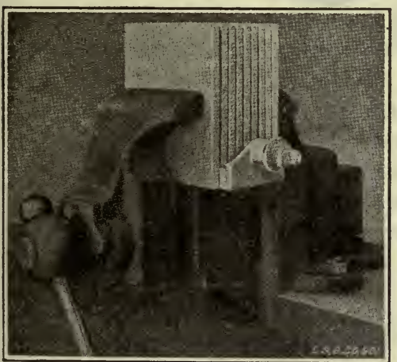


Fig. 311. Straightening Plates.

Fig. 312. Terminals damaged from Corrosion.

marked in their case. A slow charge will usually remedy this. Care should be used to keep the negative groups from unnecessary exposure to the air. If left exposed to the air for more than an hour the negative plates dry out, heat and harden.

If necessary to leave the battery in a dismantled condition the separated groups should be left in water or weak electrolyte.

Judging the Value of the Battery Case.—Unless the case shows

signs of rotting around the upper edges it is usually sound. The rapid depreciation of some cases is due to the electrolyte being spilled on them. The acid in the electrolyte attacks the wood once it has penetrated the paint. The case should always be cleaned and painted with asphaltum or other acid resisting paint, both on the inside and the outside. If in a state of saturation from the acid the case should first be washed in a baking soda solution, after which it is permitted to dry before painting.

Judging the Value of Jars and Jar Covers.—The hard rubber jars are subject to physical damage from blows as from the sudden drop-

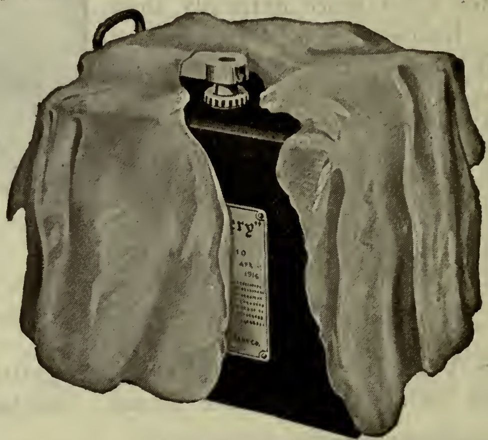


Fig. 313. Battery Covered with Wet Cloth before Lead Burning.

ping of the battery. Heating the jar in boiling water leaves it a bit more pliable and this is sometimes advisable in assembling. The least sign of a flaw should be sufficient to cause the jar to be discarded. The covers are very frequently damaged in the process of disassembling a battery, especially those which have the element in a buckled condition. Wherever this is the case the damaged cover must be replaced with a new one.

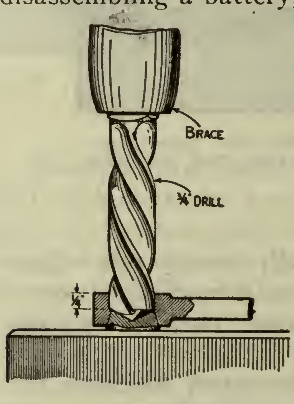


Fig. 314.

JOB 101. OPENING BATTERIES FOR INSPECTION AND REPAIR.

Removing Connecting Straps and Terminals.—While the construction of batteries differs somewhat, practically all types have the connecting straps and the terminals burned to the group posts. Consequently in opening a battery the first thing to do is to centerpunch a hole in the exact center of each terminal and connector head. The next step is to drill each of the connectors and terminals as indicated in the illustration Fig. 314. This work may be done with the brace but where there is considerable to be done the usual practice is to install a light power drill with

adjustable stop so that the holes may be drilled quickly and to a uniform depth. Where there is a power drill available for general service this is frequently used. The depth to which the hole is drilled will vary from ¼″ to ⅜″. If the connectors do not come loose after drilling to this depth they may be loosened with the lead burning flame. While applying the flame have the strap gripped with a pair of pliers and lift as the lead is softened. Usually no heat is needed as the straps will lift off easily.

Softening Sealing Compound Around the Covers.—There are three methods of doing this work. Formerly the method illustrated in Figs. 315 and

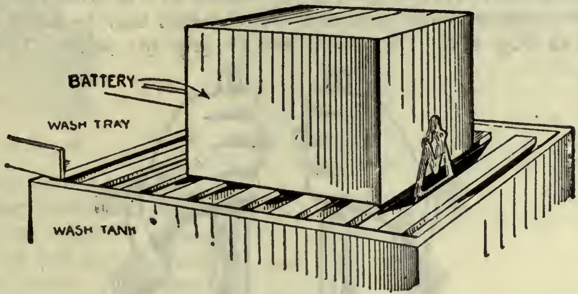


Fig. 315.

316 was used to a considerable extent. More recently the steam boiler with its individual tubes for each cell has met with much favor in the service stations and repair shops. Where the amount of work handled is not so great the gas flame is used.

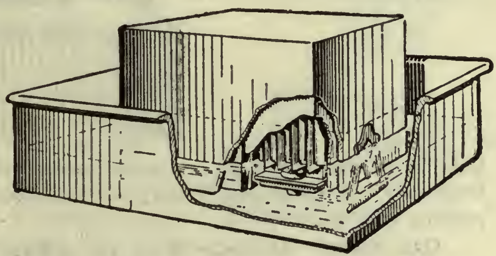


Fig. 316.

Hot Water Method.—The top of the battery should be thoroughly cleaned of lead borings and dirt after which the vent plugs are removed. The battery is placed upside down on the wash trough Fig. 315 and the electrolyte allowed to drain.

A tank of hot water is provided. This may be a large pan heated over the gas flame. There should be sufficient water to come to a point at least 2″ over

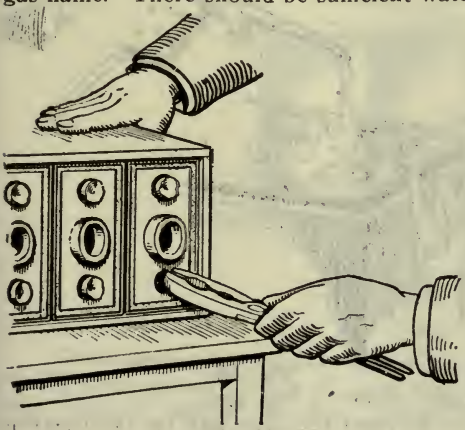


Fig. 317.

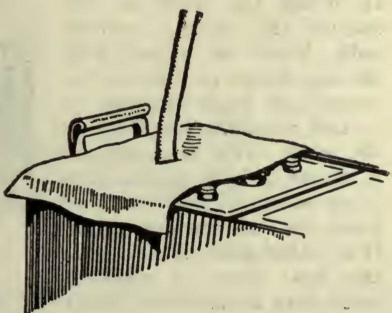


Fig. 318.

the sides of the case. If the water is boiling, five minutes will leave the compound soft enough to work. The battery may now be placed on its side on the table, and while holding with one hand the workman gives a series of pulls on the posts, using a pair of gas pliers and alternating from one post to the other until the element of that cell is broken loose and pulled out. Refer to Fig. 317.

Steam Method.—If the entire battery is to be opened, the vent plugs are removed and the steam jets are placed one in each vent. It is not necessary to remove the electrolyte in this case. Allow the steam to flow until the compound over the covers is quite soft. Refer to Fig. 318.

After the compound has softened the elements may be lifted from the cells as indicated in Fig. 319. Use gas pliers to grip the posts. If the battery is held in a vise the work is made easier. If no vise is available it may be necessary to place the battery on the floor and hold it with the foot while pulling on the posts.

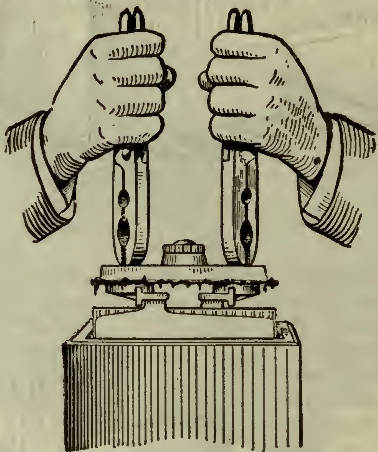


Fig. 319.

Gas Flame Method.—With an ordinary gas flame heat the compound around the edges of the cover. It is necessary to keep the flame moving so that the cover is not burned. The compound should be removed with a narrow, heated chisel. In doing the work in this manner the operator continually heats the chisel with the gas flame to prevent the compound from sticking to it, and assist in speeding up the work. If a flame is used it should be yellow since this is not as hot as the blue flame from the lead burning torch. If no other flame is available, the heat from a gasoline torch may be used but this is an operation requiring extreme care. Refer to Fig. 320.

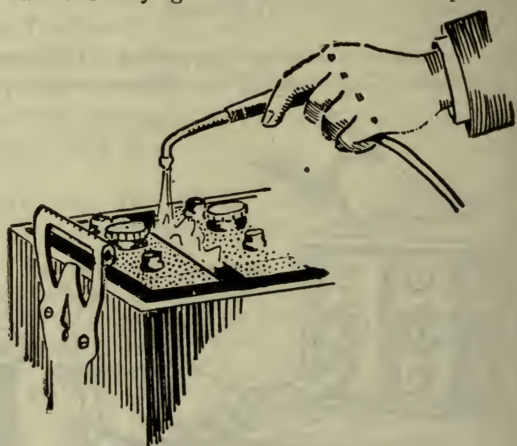


Fig. 320.

Since the steam boiler outfit is to be preferred, it is well for the operator

to provide himself with a boiler. If nothing else is available, an old can or tea kettle may be used. The tubes used to convey the steam are rubber. In the case of the tea kettle they may be attached to the spout. Since no pressure is required the lid will be all the cover necessary. It also serves as a safety valve.

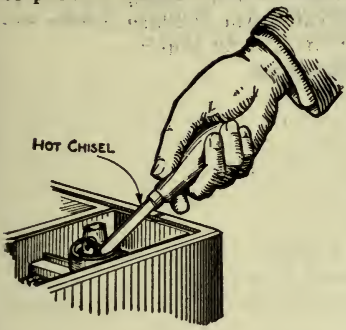


Fig. 321.

Cleaning Parts of Compound.—With a putty knife or chisel all the surplus compound should be removed from the covers and around the posts. Be certain to get every part quite clean. The method of cleaning the post well with a screw-driver is shown in Fig. 321. Remove any compound from the top inside edges of the jars as shown in Fig. 322. If this is not done trouble will be experienced in refitting the element and cover.

Removing Sediment.—As explained in the forepart of the chapter, as the active material wears a sediment collects at the bottom of the cell jar between the ribs on which the element rests. To clean this sediment out of the jar the box is placed on the washstand and a stream of water is thrown into it which washes all the parts clean. Refer to Fig. 323.

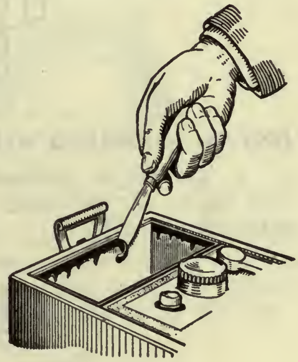


Fig. 322.

Care of Elements and Electrolyte.—When the element is first withdrawn it may be set on top of the jar, as shown in Fig. 324, where it is allowed to drain. When thoroughly drained it is separated for inspection and repairs. The electrolyte should be tested for specific gravity in order that less trouble is experienced in recharging when refilled after the repairs are made. The old electrolyte may be used although new is better. If the old is to be used it should be poured from the jars into an earthenware or glass vessel and allowed to settle. When replacing carefully pour off and use the clear portion only.

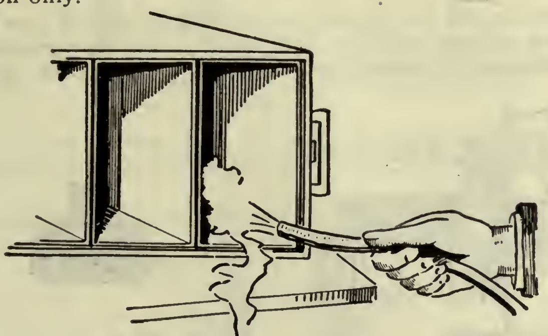


Fig. 323.

Cover Sealing.—A number of special types of covers are in use. The point in the cover through which the post projects is the hardest part to seal. With the idea of making the part leak-proof the several manufacturers have

developed special methods and designs of manufacture and sealing. Jobs 102, 109 and 110 give the method of opening and resealing the Willard, Exide, and Cincinnati types, since these are fairly representative of all types.

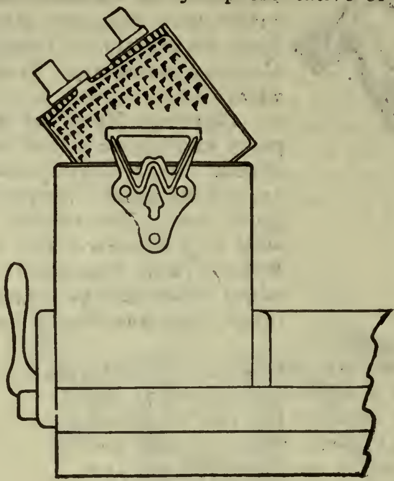


Fig. 324.

JOB 102. OPENING WILLARD TYPE "SJWN" AND "SJRN" BATTERY

1. Cut off the terminal posts as illustrated in Fig. 325, using a hack saw. This applies for the clamp terminal. If burned on terminals are used drill off with a 13/16" drill.

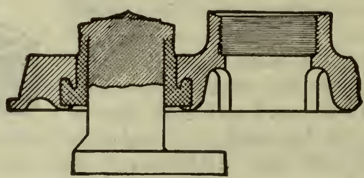


Fig. 325.

2. To remove the top connectors, place drill jig Z72 over the top of the connector head drilling with the same drill as for the terminals. Drill to a depth just sufficient to remove the connector or strap from the posts. Refer to Fig. 326.

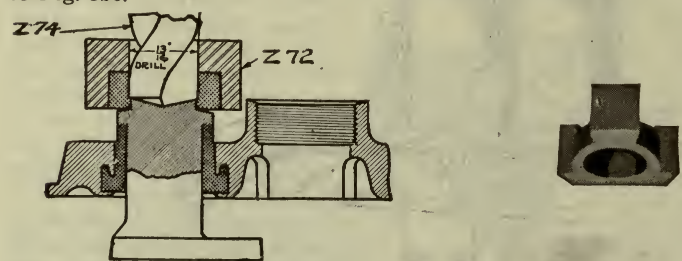


Fig. 326.

3. Use a coarse file to smooth off the post extensions left by operation 2. This leaves a flat surface on the top of the insert in the special Willard cover,

making it easier to center the drill for the next operation. Refer to Fig. 327.

4. To release the posts from the insert where they are burned together

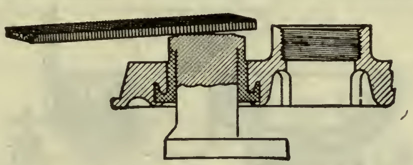


Fig. 327.

just at the insert top, it is necessary to use a 57/64″ drill. The Jig Z94 is made with a slight variation of internal diameters so that one end will fit over the insert. For method of use refer to Fig. 328.

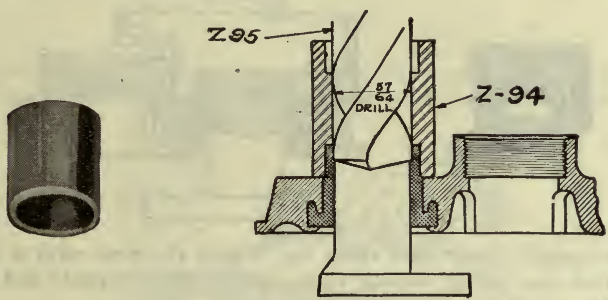


Fig. 328.

5. With post builder Z93 all connecting strap posts are built to a height of 1 5/16″ above the top of the connecting strap which holds the group together. After removing the post builder the top of the post is beveled to permit of easy assembly of the cover. The bevel is indicated at A, Fig. 329.

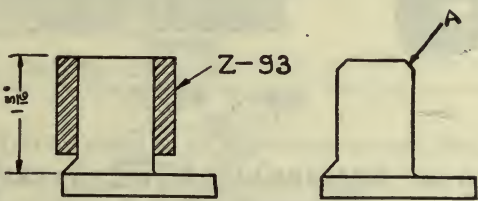


Fig. 329.

6. The elements, having been repaired, may now be replaced in the jars so that the positive terminal is to the front when the name plate end is to the right.

7. File and clean the cover inserts at Point A, Fig. 330, to a point 3/16″

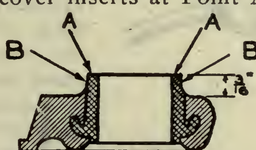


Fig. 330.

above the cover. Be certain to remove any roughness caused by the pliers at point B while handling.

8. Replace the covers so that their top edges are $\frac{1}{32}$" above the top edge of the jars, tapping lightly with the hammer. Refer to Fig. 331.

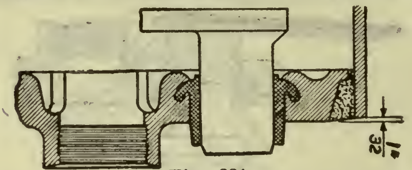


Fig. 331.

9. To weld or burn the post and insert together and form a perfect seal, the burning form Z87 is first placed over the post and insert and then the flame is applied. Refer to Fig. 332.

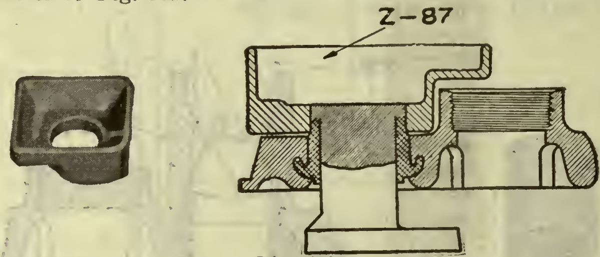


Fig. 332.

10. Thoroughly brush and clean the top of the post with a wire brush. Build up a stub post using burning form Z88 on positive posts and Z89 on the negative posts. Refer to Fig. 333.

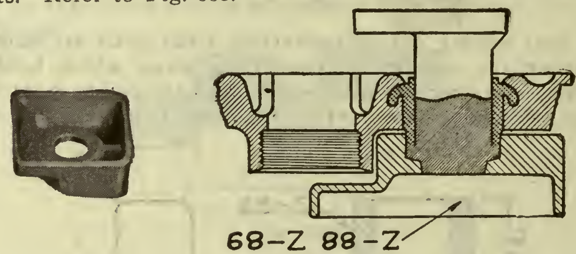


Fig. 333.

11. Proceed with the job finishing it up as indicated in Job 103.

JOB 103. REASSEMBLING THE BATTERY.

1. Having made all repairs the elements may be reassembled in the jars and the covers sealed in place. In order that the covers may be placed quickly and a fit insured they are taken one at a time and carefully fitted to the jar and element they are to cover. Remove the covers taking care to place them so that they are not mixed in replacing. Next use the gas flame to warm the cover well about the post. This will also insure the parts being dry, which is absolutely essential to a perfect seal. Refer to Fig. 334.

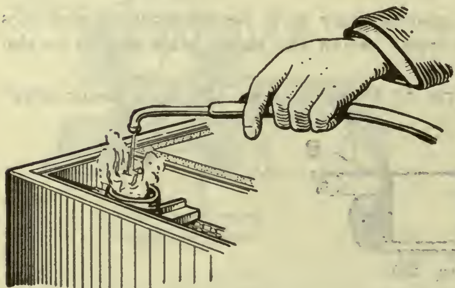


Fig. 334.

2. After warming the well of the post with the gas flame, pour in melted sealing compound until the well is nearly full. While still hot the cover must be pressed into position. This insures the parts being sealed tightly. The method of pouring the well is shown in Fig. 335.

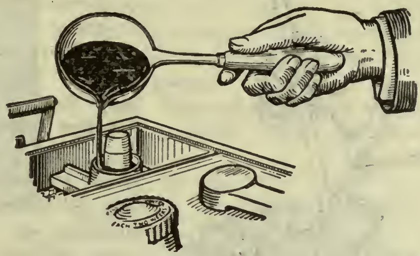


Fig. 335.

3. Using a gas flame as indicated in Fig. 336A, the workman should carefully dry the space between the jar edges and the cover. With a pouring

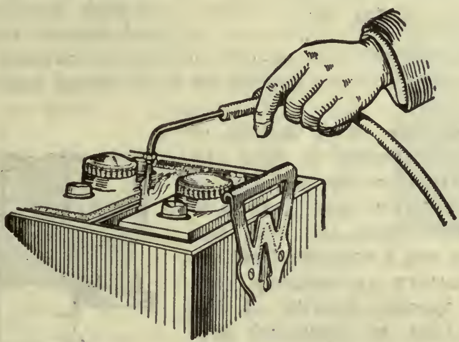


Fig 336A.

dipper, Fig. 336B, pour the space between the jar and cover about one-half full of sealing compound. After this first amount has had an opportunity to cool

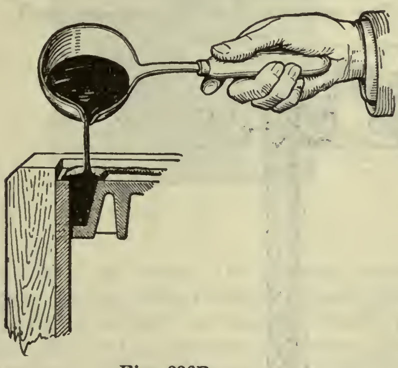


Fig. 336B.

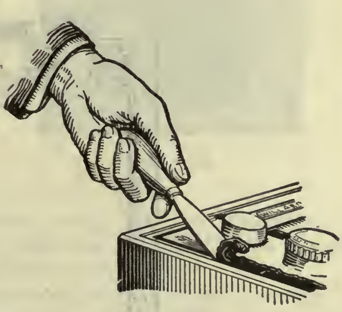


Fig. 336C.

and set, the space is filled a little more than full of the sealing compound. A steady motion is needed in pouring in order that the job has the appearance of careful workmanship when it is finished. With a heated putty knife, Fig.

336C, the portion of the compound above the cover and the jar may be carefully removed. The heat in the blade will leave the job smooth.

4. If care has been used in removing the terminals and the straps, the posts will need but little cleaning to permit the strap and terminals to come to their correct position one-fourth inch above the cell covers. The post and connector may be burned together in the manner indicated in Fig. 337.

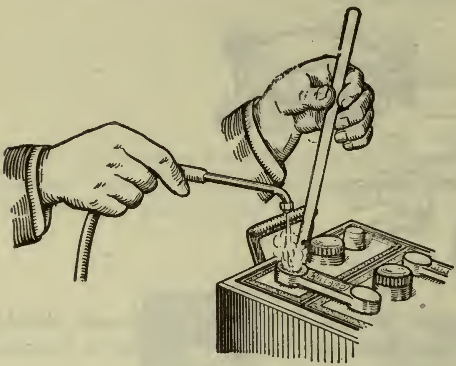


Fig. 337.

If the post in any case is too short to permit of proper assembly, it should be lengthened by building up. To do this place a post builder, which is nothing more than a piece of iron with a proper size hole in it, over the stub, use the lead burning flame to melt the lead into the mold, and fuse it with the top of the stub post. In this way the post may be built to the desired height. After the post is right the connectors are burned on in the usual manner. Refer to Fig. 338.

Very frequently the clamp instead of the burned type of terminal is used. In case of this construction the old post is very frequently undersize and otherwise imperfect. In such case the old one should be removed and a new one built up.

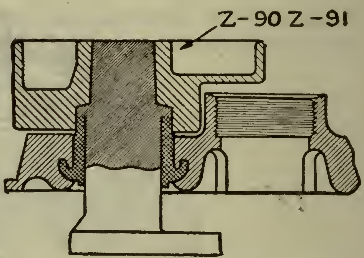


Fig. 338.

5. Fill the battery immediately it is assembled, with specific gravity of the proper density. This as indicated previously will be the same as that removed. Where new wood separators are used the electrolyte may be 25 to 50 points higher. Be certain to have plenty of solution above the plates but do not fill too full. A sectional cut of a battery shown in Fig. 339 will show the proper level.

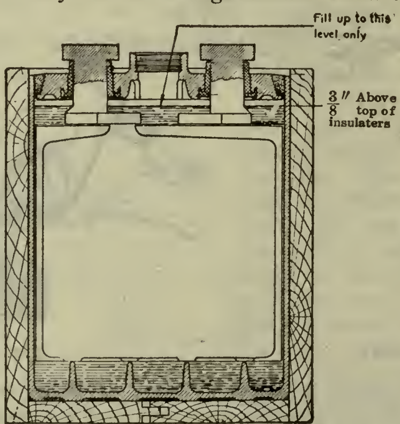


Fig. 339.

JOB 104. ELEMENT REPAIR AND INSPECTION.

1. With the battery open the separators are removed from the element in order to permit of plate inspection. If the cover has been removed the positive and negative groups are also separated. The method of doing this is illustrated in Fig. 340. Fig. 341 shows the method of removing the separators in this case, after the groups have been pulled apart.

Fig. 340.

2. Inspect all plates as suggested in forepart of the chapter. Also inspect separators, cells and case.

3. In case one or two plates of a group are bad while the others are judged fit for further service the bad ones should be removed. To do this, use a hack saw making a cut through the strap on each side of the defective plate. Place the new plate in position, having all of the group assembled on the burning rack. With the lead burning flame burn the parts together.

4. A very frequent cause of trouble with a single cell is a bad insulator, which permits of a short circuit.

5. Another cause is defective burning in. It may be of a nature hard to locate until trouble develops in service.

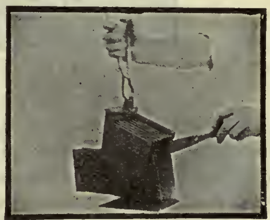


Fig. 341.

6. When part of a group of plates is worn out in normal service it is not as a rule advisable to replace them with new ones. Rather the entire group should be replaced. If it is a case of all groups being practically worn out the battery should not be rebuilt but replaced with another.

7. When the groups are in good condition they are cleaned and reassembled ready for the separators. Fig. 342 shows the method of placing the positive and negative groups together.

Fig. 342.

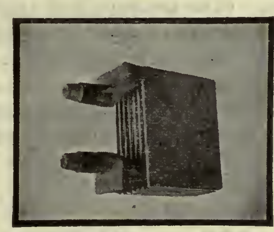


Fig. 343.

8. Fig. 343 shows the element complete except for the separators. The negative group always has one more plate than the positive. This permits of the negative plates forming the outside plate in every case.

9. Fig. 344 shows the method of placing separators in the element. One separator is placed between each two plates. The ribs on the wood separator always go next to the positive plates. In cases where other forms of separators are used the same principle holds. They should be assembled to allow as much of the positive plate surface free as is possible. The repairman

Fig. 344.

should make certain that the separators project slightly on the sides and top. Since the element rests on the cell ribs the bottom is left flush.

10. Fig. 345 shows the element complete ready for placing in the jar.

11. In placing the element in the jar use reasonable care that it does not bind at any point in such manner that the jar is likely to be broken. Fig. 346 shows a jar broken as the result of careless handling. A battery will not stand being dropped from any height onto a hard surface. To drop it an inch may result in broken jars.

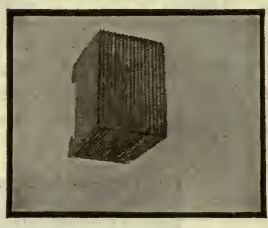


Fig. 345.

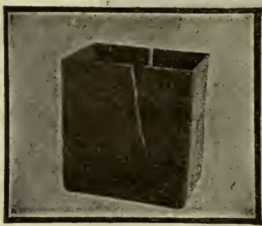


Fig. 346.

12. To remove a broken jar it is necessary to heat it with hot water or steam for at least five minutes. It may be poured full of boiling water, after which it should be removed by pulling up on it with two pairs of pliers as shown in Fig. 347.

Fig. 347.

13. Before replacing the new jar it is well to heat it in the same manner as the old one. In the meantime remove any sealing compound which might obstruct the placing of the new jar. When the jar is in position it is sealed in the same manner as the old one. This varies somewhat for different batteries. In some cases the jars are not sealed at all, in others they are sealed at the top edge, and in still others they are sealed all around.

14. The use of hot water to soften all hard rubber parts is recommended to the student mechanic. This leaves the covers and jars in a semi-pliable state with the result that there is less likelihood of their being broken as they are handled.

15. The three most common methods of grouping cells in the battery boxes are shown in Fig. 348.

JOB 105. BATTERY SHOP REPAIR METHODS.

General Test to Determine the Condition of the Storage Battery.—The first test to be applied to the battery when it comes to the repair shop for charging or repair is one to determine the voltage on open circuit. This should be six volts or a little higher for a three cell battery, correspondingly more for other types. An instrument similar to the Weston Model 441 Faultfinder should be used for this test using the 30 volt range. Having made the test on open circuit, i. e., without the battery discharging, a resistor for making a discharge test reading on the voltmeter is then connected across the battery terminals.

The resistor is made from nine feet of No. 16 soft iron wire. The inherent resistance of the iron will prevent more than a certain amount of current

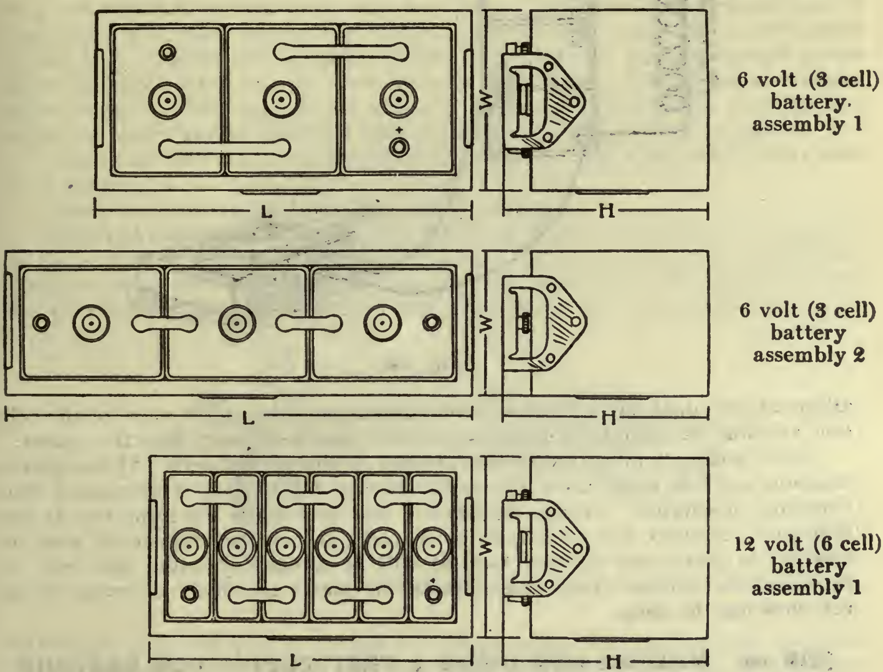


Fig. 348.

flowing. Connect the resistor and instrument as shown in Fig. 349. If the voltmeter is now below five volts the battery is either discharged or in poor physical condition.

Allowing the resistor to remain as before, the instrument is connected to make a reading on the three volt range while testing the individual cells. If

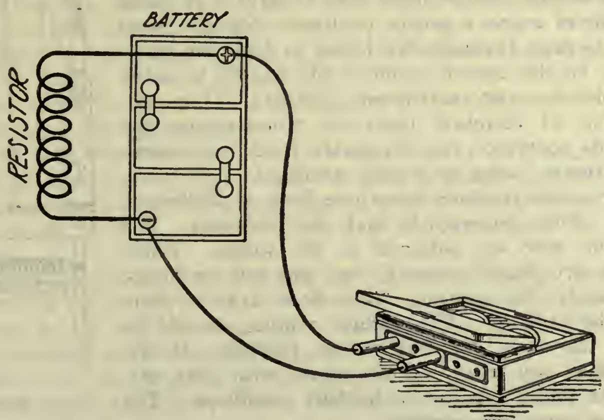


Fig. 349.

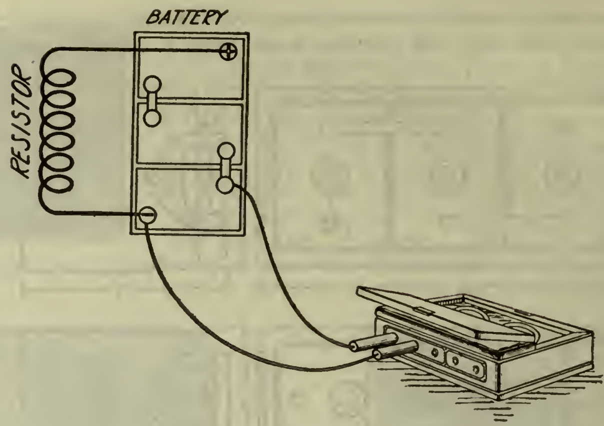


Fig. 350.

all are about equal, the battery is likely discharged. If one or more of the cells give readings exceptionally low it is possible that these have defective plates.

Next make a test for the specific gravity of the several cells. If the gravity readings are low in all cases this indicates that the battery is exhausted from continued discharge. Charge the battery and then make the same test as just indicated. If there are no defects in the cells the voltage registered with the resistor in place and current flowing will be about two volts per cell. If, however, the voltage drops considerably the plates are likely defective in the cell showing the drop.

JOB 106. MAKING AND USING A TEST OUTFIT FOR READING VOLTAGE OF INDIVIDUAL CELLS WITH CLOSED CIRCUIT.

First secure two five-inch spike nails. Grind the ends of these to a sharp point. Next take a block of fiber or hard wood four inches long and approximately one inch square as a support for the spikes. Drill holes through the wood block one-half inch from each end in which mount the spikes. To secure them in position use the hand drill to drill a $\frac{3}{32}''$ hole through them as they are in position. Place a rivet pin or cotterkey through the holes to lock the parts together. In the center mount a file handle to serve as a handle for the instrument. Refer to Fig. 351. Some form of terminal must be mounted on the spike heads to which the terminals from the instrument (voltmeter) may be readily attached.

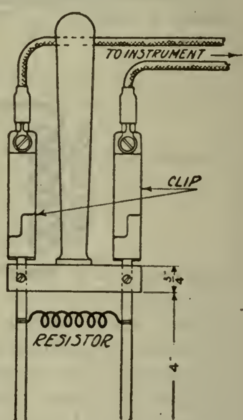


Fig. 351

The resistor is made from one foot of Nichrome resistance wire one-eighth inch in diameter. The ends of the wire are soldered to the spikes. When the spikes are firmly pressed into the cell terminals approximately 50 amperes will flow across them through the resistor. The voltage reading should be made at the time the current is flowing. If the voltage does not read 1.6 or more with this discharge, the plates are not in healthy condition. The cells failing must be repaired.

JOB 107. CADMIUM TEST.

The purpose of the cadmium test is to determine which group of the plates in a cell which is known to be bad is at fault. Since the fact remains that if one group is at fault the battery must be opened, little value can be attributed to the test. Unless the operator is one well versed in the theory and action of the storage battery the test may be very misleading. For the expert battery repair man the test may be of value in showing which group contains the defective plates and in that way save some time in making the repairs.

For those who desire to undertake the test the following instructions may be a guide:

Have the battery in fully charged condition.

The lead attached to the spike having the cadmium stick should be connected to the voltmeter terminal marked three volts. Connect the lead attached to the other spike to the terminal of the voltmeter. Insert the cadmium stick into the vent hole of the cell under test, Fig. 352, taking care that it does not come

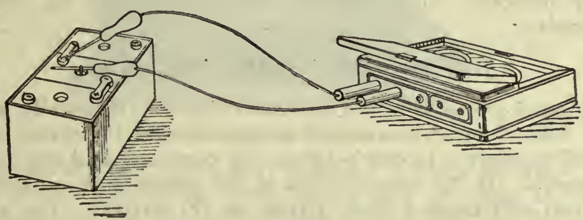


Fig. 352.

in contact with the plates. Press the other spike into the positive terminal of the cell and with the finishing rate of charging current passing into the cell observe the reading of the voltmeter. The cadmium stick should be kept in the electrolyte sufficiently long before taking the reading until the voltage does not show any changing. If the positive plates are in good condition the reading will be between 2.35 and 2.45 volts.

If the reading is less than 2.35 volts it is probable that the positive plates are defective.

Transfer the spike from the positive terminal to the negative terminal. The reading this time will be to the left of zero for a fully charged negative in good condition and should be between 0.1 and 0.2 volt. If the reading approaches zero, or if it is to the right of zero, the negative plates are probably defective.

If the test on both the positive and negative give readings which approach zero, the battery is short circuited.

In general it is understood in the case of a battery on charge that if the cadmium test to the negative plates does not give a minus reading the battery is not up to capacity, but on the other hand, a minus reading is not proof that the battery is up to full capacity. This can be determined by making a discharge test.

The battery should be discharged at its normal discharge rate until the voltage per cell is 1.8 volts with current flowing. Keep a record of the time in hours required to do this. Then with a discharge current of five amperes flowing the cadmium tests should be repeated.

The reading of the positive plates should be about 2.05 volts and the negative plates should show 0.25 volt to the right or plus.

If the reading to the positive group is much below two volts, it is certain

that the positive group is defective. If the reading to the negative plates is greater than 0.25 plus, it is probable the negative group is defective.

When the readings indicate defective plates, it is best to open the cells and make a further inspection of the plates.

Upon reaching the voltage of 1.8 volt per cell the battery should have given its rated ampere hour capacity. This is determined by multiplying the ampere discharge rate by the length of time rated in hours, which has been necessary to discharge the battery to that point. If the full capacity of the battery has not been given it is probable that the plates are defective, and the cells should be opened up and the plates given further inspection.

When the cadmium tests show the plates to be in fully charged condition, the gravity of the electrolyte should be determined. This should be between 1.275 and 1.300. If it is not, it should be corrected until it does show the proper density.

If the density indicates a fully charged cell, but the cadmium readings do not show fully charged plates, the charge should be continued to see if the cadmium readings will not become what they ought to be. If not, the plates are probably defective. The battery should be opened up and receive the necessary repairs.

JOB 108. GROUNDED BATTERY.

As mentioned previously, the grounded battery is usually due to spilled electrolyte. This electrolyte, coming in contact with the metal box or battery container, will produce a circuit between the container and one or more of the battery terminals. If the system used is the single wire or grounded return this new circuit will cause a short circuit on the battery. For a short circuit to develop on the two-wire system both the positive and negative terminals must be grounded simultaneously.

To test the grounded return system, first remove the ground connection. Connect the 30 volt range of the Fault Finder between this terminal and the frame of the car. Any indication on the instrument will be due to a short circuit to the car frame from the other battery terminal.

In the two-wire system each battery terminal should be tested for ground to the car frame.

In all cases it is very important to remove all moisture from the top of the battery. This will often remove the cause of the ground. In some instances the battery case is so saturated with the electrolyte that it is hard to remove the cause of the short circuit. Cracked cells may be the cause of short circuits.

JOB 109. REMOVING AND RESEALING EXIDE SINGLE COVER TYPE COVERS.

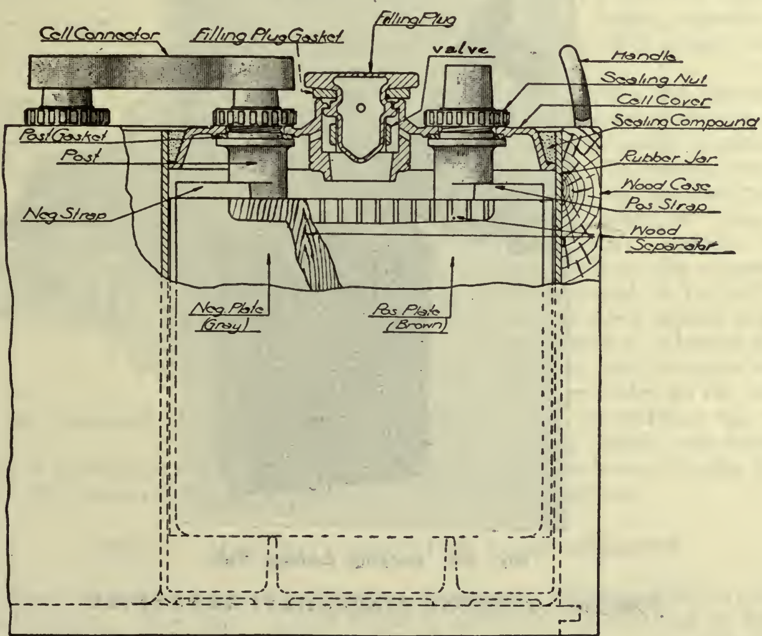
1. Remove the lead straps. These may be bored with a five-eighths inch wood bit as indicated in Fig. 353. Just under the lead straps the special form of lock nut is visible. These nuts are used to seal the joint where the post comes through the cover. The section of an Exide battery, as shown in Fig. 354, indicates the secure manner in which the parts are locked together. The sealing compound locking the elements in the jars may be softened by one of the methods indicated in Job 101, after which the elements may be removed from the cells.

2. To remove the sealing nuts the special wrench shown in Fig. 357 should be used.

3. After repairs are made to the element it is assembled in the cover and the sealing nuts are tightened part way, using only the fingers for this work.

Fig. 353. Boring Connector.

Be very certain to have the soft rubber washers in place in order to make a tight joint and protect the cover. With the groups on edge, as indicated in Fig. 355, the separators are inserted making certain that the flat side of the wood is against the negative plates.



Section of Battery—Burned Connections, Single Flange Cover

Fig. 354.

4. With the separators all in place and projecting equally on each side the sealing nuts are locked tight using the special wrench.

5. The sealing nut should be locked in position as indicated in Fig. 356.

Fig. 357. Sealing Nut Wrench.

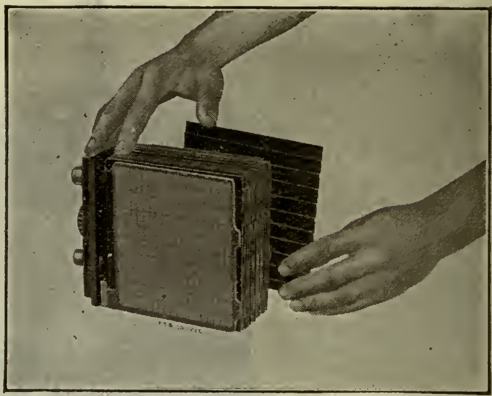


Fig. 355. Inserting Separators.

A center punch or nail may be used to punch several points to prevent the nut working loose.

Fig. 356. Locking Sealing Nut.

JOB 110. OPENING CINCINNATI BATTERIES.

Fig. 359 shows the patented feature of the Cincinnati storage battery cover locking device. On the group post, just above the point where the cover fits,

is a threaded portion. Projecting above this threaded portion is a round smooth post. The nut which is used to lock the cover to the group has a nipple-like arrangement on its top which fits over the smooth part of the post when the threaded portion of the nut locks over the threaded portion of the post. To dismantle, proceed as follow:

1. Centerpunch the centers of the connecting straps and terminals over the post.

2. Drill with a ⅝" drill to a depth of one-fourth inch and remove the straps and terminals.

3. Inspect the post tops to learn if the line of separation between the inner post and the nut is evident. If not apparent it is useless to attempt to turn off the nut. Use a file to file off the top of the post and nut until the line or circle between the two appears.

Fig. 358. Cincinnati Storage Battery.

4. Place a socket wrench over the hexagonal portion of the nut and turn or back it off the post.

5. After loosening the nut it may be desirable to turn it back in position until the covers are loosened in the usual manner by steaming, hot water, or gas flame.

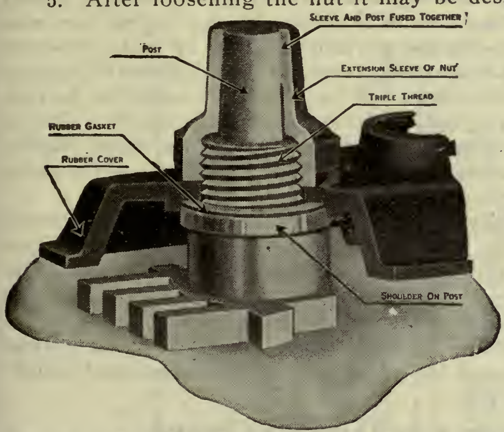


Fig. 359. Cincinnati Storage Battery Cover Locking Device.

6. When the element is finally removed the cover is quickly removed by releasing the nuts. In reassembling be certain to use the soft rubber washers under the nuts.

7. After repairs have been made to the element, it is assembled in the cell jar and the cover placed in position, where it is locked under the nuts, and the outer edges of it are sealed to the jar.

8. In burning the connecting straps and terminal posts in position the upper edge of the nut will again be burned to the inside post. This insures the nut remaining permanently in position.

JOB 111. MAKING AND USING ELECTROLYTE.

Electrolyte, as explained previously, is made by adding sulphuric acid to distilled water. The water should never be added to the acid, but in mixing the acid is always added to the water. If the operation is reversed the water striking the acid is very likely to cause such violent action as to throw the

solution from the receptacle in which it is being mixed. The amount of acid added to the water determines its specific gravity.

Making Electrolyte.—In making up the electrolyte, glass jars or earthen jars should be used. Metal containers outside of burned lead vessels may not be used. It is well also to have a glass funnel and syringe available. The syringe may be an old hydrometer case with the hydrometer removed.

When mixing the acid and water they are figured not by weight, but by volume. For electrolyte of varying specific gravity consult the following table. The student will remember the specific gravity of water as 1.000, and of pure sulphuric acid as 1.835. In purchasing the acid it must be ordered from the chemical company or supply house as C. P., H_2SO_4, which is chemically pure sulphuric acid. The distilled water may be secured from the same source.

1.150 Sp. Gr. equals one part sulphuric acid to 6 parts distilled water.
1.200 Sp. Gr. equals one part sulphuric acid to 4 parts distilled water.
1.250 Sp. Gr. equals one part sulphuric acid to 3 parts distilled water.
1.285 Sp. Gr. equals one part sulphuric acid to 2.5 parts distilled water.
1.325 Sp. Gr. equals one part sulphuric acid to 2 parts distilled water.

Allow the electrolyte to cool below 90 degrees F. before putting it into the cells of the battery.

Filling the Battery with Electrolyte.—All cells should be filled with electrolyte up to one-half inch over the top of the plates. If the elements have been out of the jars long enough to allow the plates to dry out, the battery must be left for at least eight hours after filling before placing on charge.

Determining Strength of Electrolyte to Use in a Repaired Battery.—If the plates are new the electrolyte used for filling should have a specific gravity of 1.325; if they are old plates badly sulphated, the electrolyte should be 1.150 specific gravity, while if old plates, and any doubt about their condition is held by the workman, the electrolyte used should be 1.200. To the student it is now apparent that if the specific gravity of the electrolyte drawn off were known it would be easier to know just what specific gravity to fill the repaired battery with. All acid which may be in the plates will be forced out when the battery is charged and will increase the strength or density of the electrolyte. This is true of all old plates, but in the case of new plates the gravity drops slightly since some acid is always retained in the plates. This is the reason for using the 1.325 electrolyte when filling over new plates.

Adjusting Electrolyte.—A fully charged battery should show a specific gravity of 1.280 to 1.300. If, after the cells are fully charged, the electrolyte is not of the proper density, the proper correction must be made. If too high, the cell must have a portion of its electrolyte drawn off with the syringe and a like amount of distilled water added. If too low, a quantity of the electrolyte is drawn off and electrolyte of 1.400 specific gravity is added After the change is made the charge must be continued for a time and then final tests and adjustments made.

JOB 112. CHARGING A REPAIRED BATTERY.

The battery should be placed on charge at a low rate. approximately that of the finish rate stamped on the name plate. It may be continued on charge until there is no further rise in gravity in any of the cells. A reliable thermometer must be used to check up the temperature. If at any time the battery heats to 110 degrees F., the current must be reduced until the temperature is below 90 degrees. When no further rise is noticeable in the gravity readings for two to five hours, the gravity must be adjusted to read between 1.280 and 1.300.

Acid must never be added to bring up the gravity of a cell unless it shows no rise whatever over a period of from two to five hours. The cadmium test

is sometimes used to determine if the plates are fully charged. If a part of the cells are fully charged while others do not show a full charge, the low ones should be charged individually in an attempt to bring them to the proper gravity reading. It is only when this has failed to bring the cell above the fixed point after several hours of charging that the repairman may feel free to make adjustment of the acid. It must be definitely understood that batteries cannot be recharged by adding acid. Acid is added to the electrolyte only after all is driven from the plates by charging and then only to insure having the proper amount in the cell, that its future action may be correct as fixed by the generally accepted standards.

CHARGING BATTERIES AND BATTERY CHARGING EQUIPMENT.

The prime requisite in charging batteries is a D. C. current. A. C. current, as explained in Chapter 11, may not be used for this work. Other essentials are methods of controlling the voltage and the amperage and instruments to measure the voltage and amperage. There are many devices and methods in use for the work of battery charging. Some are simple and inexpensive. Others are very elaborate and quite expensive. The number of batteries to be cared for and the type of current or power available are determining factors in deciding on equipment as well as method. Where 110 volt D. C. lighting current is available it is comparatively simple to use it. Where it is desired to use the A. C. current some form of transformer or rectifier must be used.

Charging a Battery from a 110 Volt Lighting Circuit.—It is possible to charge from one to fifteen 6-volt batteries by this method. By referring to Fig. 360 the student will learn the method of wiring for a single battery. The

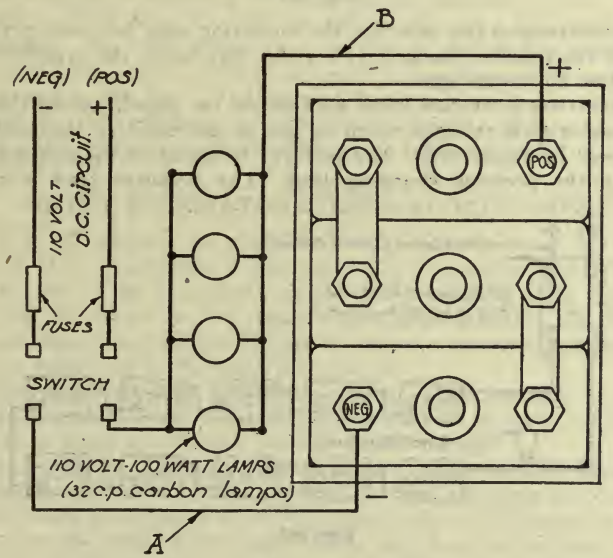


Fig. 360.

outfit consists of a board or slate panel, on which is mounted a two-pole throw-out switch for turning on and off the 110 volt current. This line must be protected with 15 ampere fuses. It is necessary to determine which line is negative and which positive. This may be determined by the use of a volt-meter, or by placing a teaspoonful of salt in a tumbler of water and dipping

the two leads from the 110 volt circuit in the tumbler. This will indicate polarity since the small gas bubbles forming on the one wire show it to be the negative lead. The insulation must be removed from the ends of the leads.

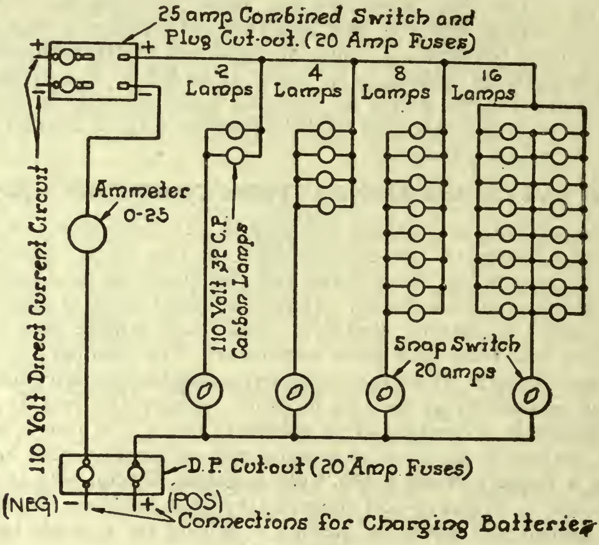


Fig. 361.

Having determined the polarity, the mounting may be made permanent on the panel and the positive marked with a plus sign while the negative is marked with a negative or minus sign.

Next mount six porcelain lamp sockets on the panel, wiring them so that the current must flow through them to get to the positive terminal to which the battery will be connected. The positive terminal of the battery is always connected to the positive charging lead. The negative lead is run to the

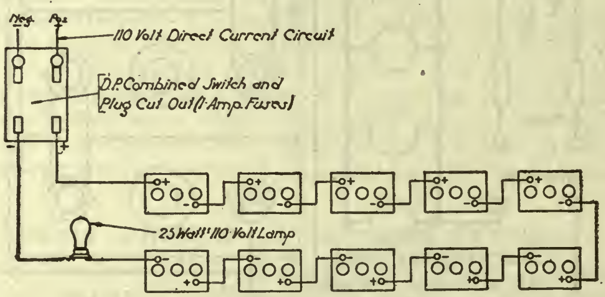


Fig. 362.

negative battery terminal direct unless the amperage flowing is desired to show on an ammeter when the battery is charging. In this case the ammeter is placed in series on the negative line.

Into each of the lamp sockets is screwed a 32 C. P. carbon bulb. The amount of current permitted to flow through one bulb is 1 ampere; through two bulbs, two amperes, and through six bulbs, six amperes. Consequently

as many amperes will flow to the battery as there are bulbs in circuit. To take a bulb out of circuit it is only necessary to back it out of the socket until it goes out. The current then is reduced one ampere. Manipulating the six bulbs will give a charging range of from one to six amperes.

Charging a Number of Batteries from 110 D. C. Circuit.—With the panel shown in Fig. 361 a number of batteries may be charged. The principle is the same as that given above. Thirty bulbs are arranged on the panel so that a charging rate varying from one to thirty amperes is available by manipulating the switches in addition to the bulbs. In making up this panel slate is to be preferred to wood although the latter may be used providing it does not interfere with the national underwriters' rules. It is best to have an ammeter in the negative line to show the amperage flowing.

In operation the amperage required will be the same as for individual batteries. Whatever flows through one cell will flow through each cell. The charging rate should not exceed the lowest maximum given for any individual battery. When the batteries are connected to the charging leads, the positive of the first battery is connected to the positive lead, the negative of the first battery is connected to the positive of the next one, and so on until the number desired are connected.

By manipulating the switches the correct charging rate may be obtained. Whatever amperage shows on the ammeter flows through each cell. To hold this at the desired point bulbs must be added or withdrawn, more bulbs for a higher rate, fewer bulbs for a lower rate.

TRICKLE CHARGE FOR BATTERIES IN STORAGE.

In wet storage of batteries it is sometimes desirable to have a very light current of electricity pass through the cells at all times so as to keep them in good condition. Fig. 362 shows one method of doing this where 110 D. C. current is available. Ten or more batteries are connected in series and only one bulb placed in the line. The current flowing is not sufficient to cause the cells to gas, but is sufficient to keep them charged. Before going into wet storage on a trickle charge, all cells should be fully charged.

MOTOR GENERATOR CHARGING EQUIPMENT.

Where A. C. current is available the equipment used for charging is frequently a D. C. generator driven by the A. C. motor which is frequently direct-connected. This equipment comes in sizes suited to all types of repair stations. For the owner or the repair shop charging only a few batteries at a time the problem is sometimes solved by using a generator from an old car, driving it by means of a one-half H. P. motor.

Charging Batteries from a 220 Volt Circuit.—It is possible to use a 220 or higher voltage circuit if the bulbs are connected two in series, or such suitable arrangement is made as will care for the higher voltage.

Charging from D. C. Using a Rheostat for Resistance and Current Regulation.—In cases where D. C. current is available for charging in a battery repair shop where much charging is done, the lamp bank on the panel is not used as frequently as some form of rheostat. These may be made up by an experienced electrician, or purchased from supply houses. When so purchased the rheostat is only part of the charging set which usually includes instruments, switches, etc.

Charging from A. C. Circuit using a Rectifier.—Numerous devices are on the market utilizing A. C. current for the source of a charging current. In every case the A. C. current is changed to D. C. current before being sent to

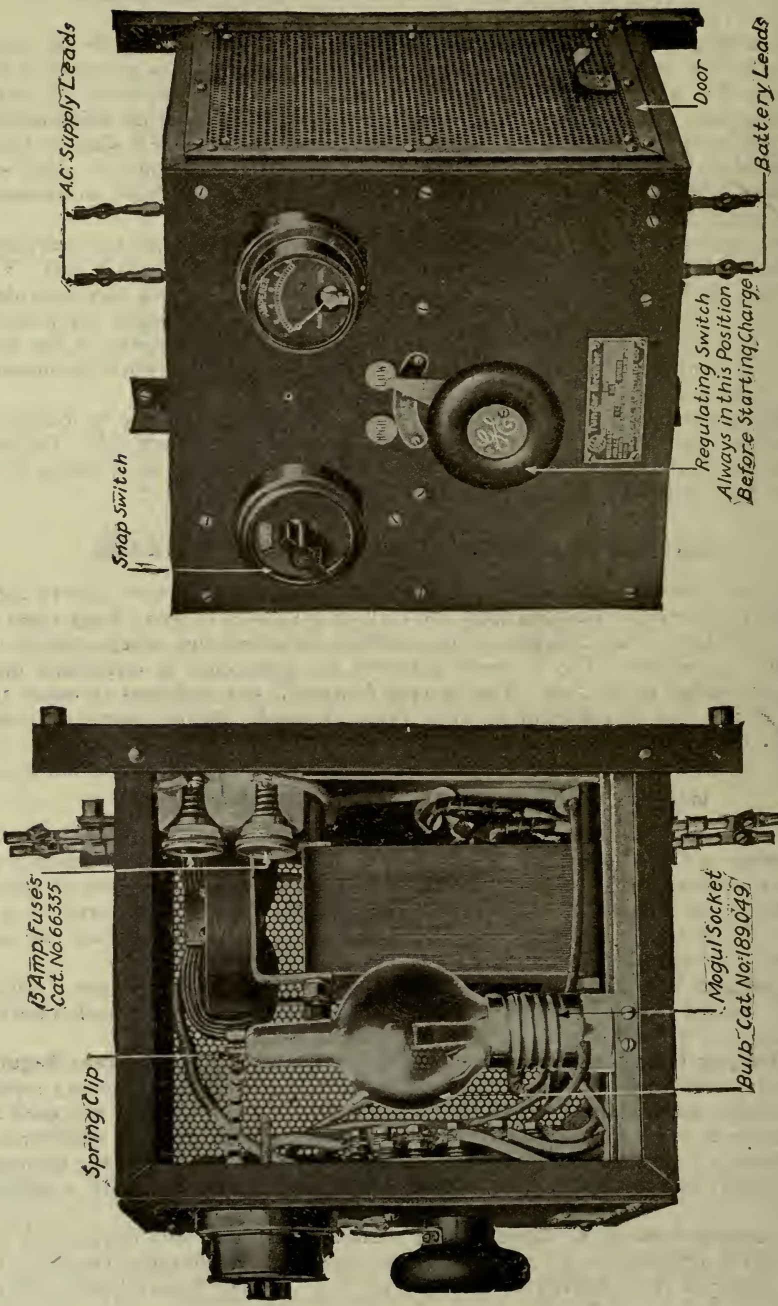


Fig. 363. Tungar Battery Charger.

the charging circuit. The mercury vapor bulb or similar lighting bulb equipment is frequently the heart of the rectifying instrument. In other instances the rectifier is a rotary machine, and in still others a vibrating machine. In every case the A. C. current which pulsates through the supply circuit in an alternating manner is so converted or rectified that the pulsations in the charging circuit all flow in one direction.

Tungar Rectifier.—This is made by the General Electric Co., and may be had in sizes suitable for charging batteries from the 110 A. C. lighting circuit. Any number of batteries from one to ten may be charged. Fig. 363 shows a photo of this equipment which is very satisfactory.

JOB 113. CARING FOR BATTERIES ON CHARGE.

The equipment needed for this work consists of a hydrometer, a syringe, a thermometer, and a test instrument similar to the Weston Fault Finder 441. Proceed as indicated below:

1. Take a hydrometer reading for each cell. Record same for future reference.
2. Take voltage reading of each cell as indicated in Jobs 106 and 107. Record the findings.
3. If the customer's report on battery and the findings from the voltage tests and hydrometer readings warrant, the battery should be put on charge at the start rate stamped on the name plate. It is far better to charge at a low rate for a longer time than to attempt to hurry the job at a high rate.
4. If the battery is a badly sulphated one, or one just rebuilt, it is better to put it on at the finish rate.
5. As the battery takes the charge it will gas slightly at first, and then as the charge nears completion, more and more freely, unless the charge rate is reduced from the start to the finish rate.
6. As the charge proceeds it is necessary to note the temperature of the electrolyte within the cells. If any one shows a rise above 110 degrees F. the charging rate must be reduced, or the battery taken off the line until it has cooled below 90 degrees.
7. In making tests with the hydrometer, the fact that electrolyte is lighter at temperatures higher than 70 must be considered. It is necessary to correct the hydrometer reading one point for each three degrees rise of the temperature of the electrolyte. For instance, if the temperature rises to 100 degrees the correction would be ten points, due to the 30 degrees rise. If the hydrometer shows a reading of 1.280, same should be corrected to read 1.290. This is very important in judging the state of charge of a battery which is partly or fully charged.
8. A battery on charge may be tested for cell voltage by merely connecting the terminals from the fault finder to the three-volt range and to the connecting straps or terminals. The reading for a cell on charge and in good physical condition should be 2.2 volts.
9. The charge must be continued until there is no further rise in gravity of any of the cells over a period of two hours. If one cell is slow in coming up to the proper point, charge it individually.
10. A cell having come in for recharge only will not as a rule require any adjustment with acid to bring it to the proper gravity reading. In case some of the electrolyte has been spilled, an adjustment is necessary. Acid does not leave the cell through evaporation. Low gravity is due to acid entering the plates. Charging drives it from the plates into the solution again and the electrolyte returns to its original gravity.

JOB 114. DISCHARGING A BATTERY.

Very frequently it is advisable to discharge a battery. A discharge test is explained in Job 107. Discharging a battery which has been charged after a long period of discharged inactivity and then recharging it will help to restore it to its normal activity. To discharge the battery proceed as follows:

1. Learn the discharge rate from the battery name plate.

2. Secure several lamp sockets such as are used for automobile lighting. Wire them in parallel, using enough to give a combined draught on the battery equal to the desired discharge rate.

4. Mount the sockets on a board and wire them. Connect the battery to them. By placing an ammeter in circuit the discharge rate may be noted and recorded.

5. Discharge until the individual cells show a voltage test of 1.8 each. Note the number of hours elapsing since the discharge was started. Multiply this by the rate of discharge. Compare the result with the rated capacity of the battery in ampere-hours.

6. Recharge the battery as in Job 112.

7. Where a great deal of discharge work is to be done, a discharging apparatus utilizing a rheostat is desirable. This may be made by the ingenious mechanic from some resistance wire. An ammeter should be arranged on the same panel in order that the discharge rate might be noted readily.

JOB 115. CARING FOR BATTERIES IN STORAGE.

When the car user lays up his car for the winter months, it is well for him to send the battery to the service station where it may receive proper care. If a home charging equipment is available, he should follow the instructions given below for a periodic charge while the battery is in wet storage.

Batteries are usually stored for the shorter periods in their normal charged condition. This is known as wet storage. To keep the battery in good condition it is necessary to supply it with a trickle charge, or give it a periodic charge at least once per month. If the battery is to be stored for a year it is best to put it in dry storage. This means charging and then disassembling.

Wet Storage.—If possible, store the batteries on a shelf or table where they may be charged without removing. This means wiring to suit the charging equipment used. Place strips of wood under the batteries so that they are not resting on the entire surface of the bottom of the case. This permits of air circulating through underneath them. Neither should the cases rest tightly against each other.

Charge the batteries fully before putting them in storage and once each month thereafter. Keep the terminals clean and coated with vaseline. If the trickle charge method of storing is used rather than the periodic charge, the battery should be fully charged before storing. Methods of charging are given in Job 112.

Dry Storage.—In this case the battery is fully charged. The electrolyte is all drained off the cells by turning the battery bottom up over a sink or some receptacle to catch the electrolyte. Before draining make a record of the specific gravity readings for the cells and save them for reference when putting the battery back in service. After the electrolyte has all drained fill the cells with distilled water and allow them to stand for five hours. After this the battery is opened up and the groups of plates are separated, cleaned and stored in a clean dry place. When the battery is put in service it is given any needed repairs and assembled and recharged as for the usual repair or overhaul job.

CHAPTER 12

BATTERY IGNITION

Automotive ignition is divided into two distinct classes, battery ignition and magneto ignition. The fundamental principles of electricity apply in each case, athough the mechanical application is different.

Battery Ignition.—This division may be said to be subdivided into two classes, the vibrating coil and the plain or non-vibrating coil. The last mentioned is the most used and is considered standard battery ignition. The units required in this case are the generator to store current in the battery, the battery to supply current to the coil, the coil and condenser to furnish the high tension spark, the breaker points, the distributor, plugs, etc.

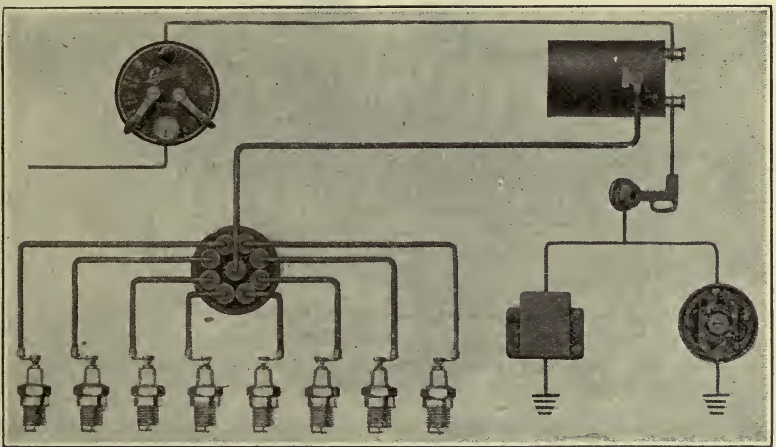


Fig. 364. Cadillac Battery Ignition.

Ignition Coil.—The spark coil or ignition coil is in reality an induction coil, in that the spark producing igniton of the fuel charge in the cylinder is an induced current. The current being induced is what is known as high tension current in that it is of sufficient pressure or voltage to cause it to jump from one electrode of the spark plug to the other through the intervening air gap. It should be remembered that air is a poor conductor or rather an insulator.

Principle of Induction Coil.—The induction coil is built up about a core of soft iron wires. These are bound together and covered with a layer of paper or other insulating material. Over this paper is wound the primary or low tension winding. This consists of several layers of insulated or enameled magnet wire of about eighteen gauge. The ends of the wire are later connected to terminal screws.

The secondary, or high tension wire, is of the enameled or cotton covered type only very much finer. The number of turns wound on over the primary winding runs between 2,000 and 3,000. This winding is carefully insulated from the primary winding and has absolutely no connection with it. The primary current or current drawn from the battery cannot and does not flow through the secondary winding. In it, however, is induced a current just as previously explained in Chapter 10, except that instead of the conductor moving through lines of force, the lines of force are caused to move through the conductor windings. To illustrate:

It has been shown how in a bar magnet or in an electro-magnet,

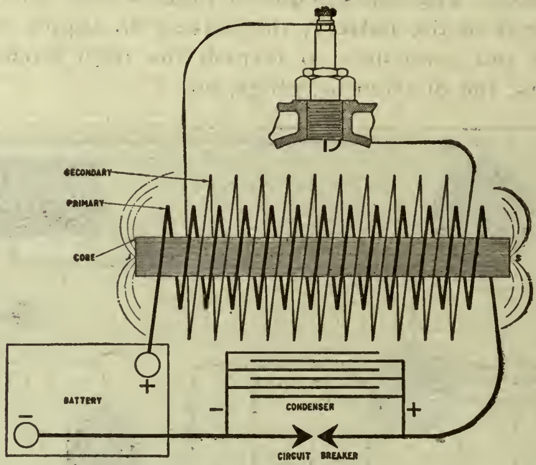


Fig. 365. Technical wiring diagram of Typical Battery Ignition. (K W Ignition Co.)

which is what the core of iron wire with its primary coil really is, the current sets up lines of force or flux which flow from the north pole to the south pole and there enter the iron core flowing back to the north pole through the core. Again, they come out and flow from the north to the south pole through the air and thence to the north pole from the south through the core, the action being a continuous one as long as the current is flowing through the primary winding from the battery. However, there is this point to be remembered: When the primary current first starts flowing through the primary coil the lines of force emanate or come from each coil of the primary winding. This happens all along the length of the primary winding after which, however, they all flow as described above as long as the current is not broken. According to the same rule, when the current is suddenly broken these lines of force flowing about the coil do not continue to the end of the core to re-enter it, but drop immediately to it from all points, thus cutting the conductor wound around the

primary coil and known as the secondary coil. It is this action of the lines of force, as they cut the conductor composing the secondary coil as they return to the core, that is usually counted on to induce the high tension current for use in ignition. Sometimes the current is induced when the lines of force come from the core. However, this action is usually less forceful and in general practice is not used. Magnetization as a rule being slower than demagnetization, the making of contact of the switch will cause some current to be induced in the secondary coil as the lines of force leave the core, but the voltage or current is not sufficient to cause the current to leap the air gap at the spark plugs. When the switch is opened, however, the demagnetization is made

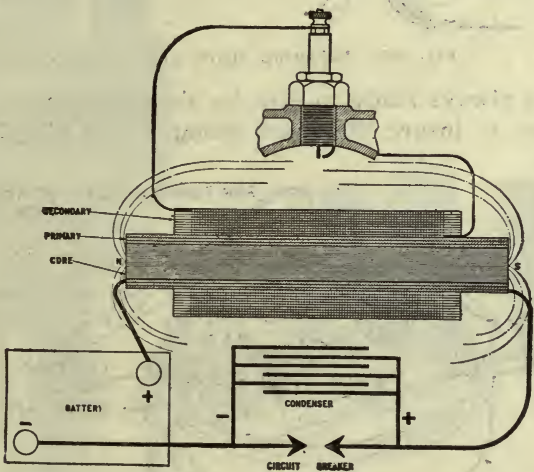


Fig. 366. Section of Typical Battery Ignition System. (K W Ignition Co.)

quite rapid through the use of the condenser. Breaking these lines of force causes them to collapse or break down very rapidly, and in such volume that a very high tension or pressure is induced within the secondary coil which they are cutting as they drop back or collapse. This pressure, varying from 15,000 to 30,000 volts, is so high that it will jump the air gap at the spark plug points. The direction of flow of the induced current is the same as that of the primary current.

Air Gap.—Several air gaps are in use with reference to the ignition system. One is the air gap provided in the spark plugs. This air gap should never be more than 1/32″. Failure of some other part of the ignition system, such as the loss of the spark plug wire from one of the plugs, might result in the high tension winding of the ignition coil being broken down and the insulation punctured if a safety gap were not provided. This safety air gap is usually ¼″ to ⅜″ long and is built into the coil. Ordinarily the high tension spark is carried through the distributor and from there to the plug but the

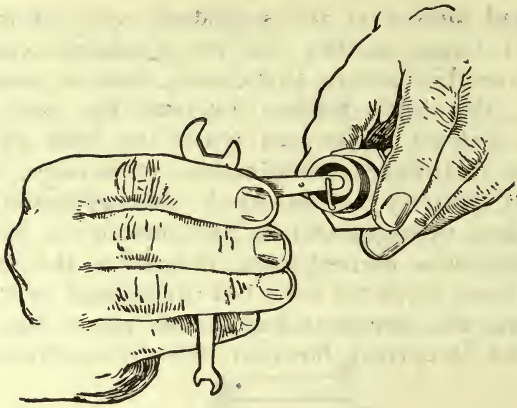


Fig. 367. Adjusting spark plug air gap.

safety gap is always ready to care for the emergency. It is made of sufficient size to insure the spark going to the plugs under normal conditions.

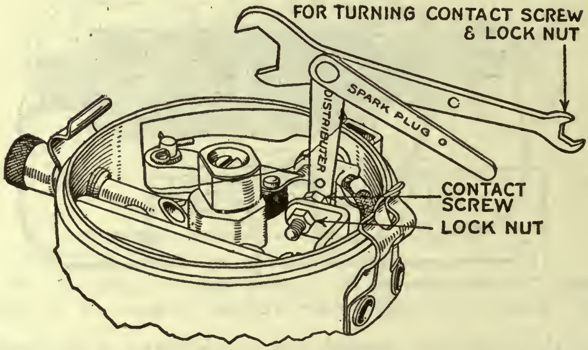


Fig. 368. Adjusting Distributor Points and testing with thickness gauge.

The resistance of the air gap increases with the compression in the cylinders. Since air is a non-conductor, it is natural that if four times normal air pressure is induced, as is the case in the cylinder, the gap will be harder to jump.

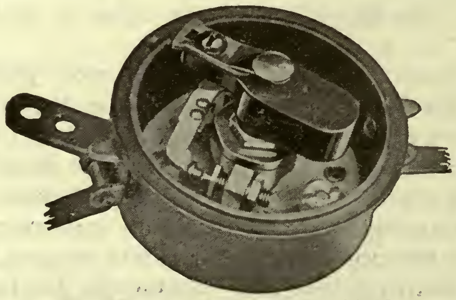


Fig. 369. Remy Distributor Head.

Timer-Distributor. — The student is familiar with the facts of engine design with reference to the four-stroke principle, and the firing order. The distributor is generally built to include the primary breaker points as well as the means of distributing the high tension current. The purpose of the timer-distributor is to make the electrical connection on the primary winding of the ignition coil, thus permitting the magnetic flux to build up. Next it must be broken at just the correct moment to permit the secondary current induced to be carried back to the distributor, and from the distributor head to the plug in the cylinder then under compression, and waiting to be

Fig. 370. Remy Apperson Ignition Distributors.

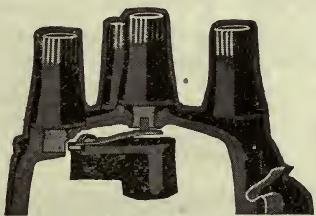


Fig. 371. Section of Atwater Kent Distributor Cap and Rotor.

fired. Here it jumps the gap, due to its tremendous pressure or voltage, and ignites the charge. It will be noted that two distinct functions are performed. The first is making and breaking the contacts for the completion of the primary circuit which might be said to be switching off and switching on of the primary circuit. Normally the current is on, thus permitting the magnetic flux to build up to a high value in the coil. However, the distributor shaft has a cam on the upper end. On this cam are machined as many lobes as there are cylinders to the engine. This cam turns at one-half engine speed so that each lobe opens and closes the breaker points once for each two revolutions of the engine. Each time the switch or breaker points are opened, a cylinder is fired.

Accordingly there must be an equal number of high tension

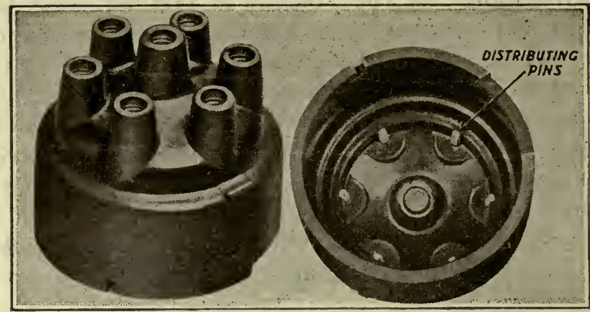


Fig. 372. Wagner Distributor Cap.

wires running from the distributor cap to the engine cylinders. Just under the distributor cap is a rotor which distributes the high tension current. This rotor receives the high tension current on the center where it is usually in contact with a spring, and sends it to that plug-wire under which or with which it is in contact. The next break of the primary current induces another high tension spark which is distributed or sent to the next plug-wire in line. The next break sends the current to the next plug-wire, and so on and on, all the way around the cap, four breaks for the four-cylinder engine, six breaks for the six-cylinder, and so on. Needless to say the firing order of the engine must be considered in running the wires from

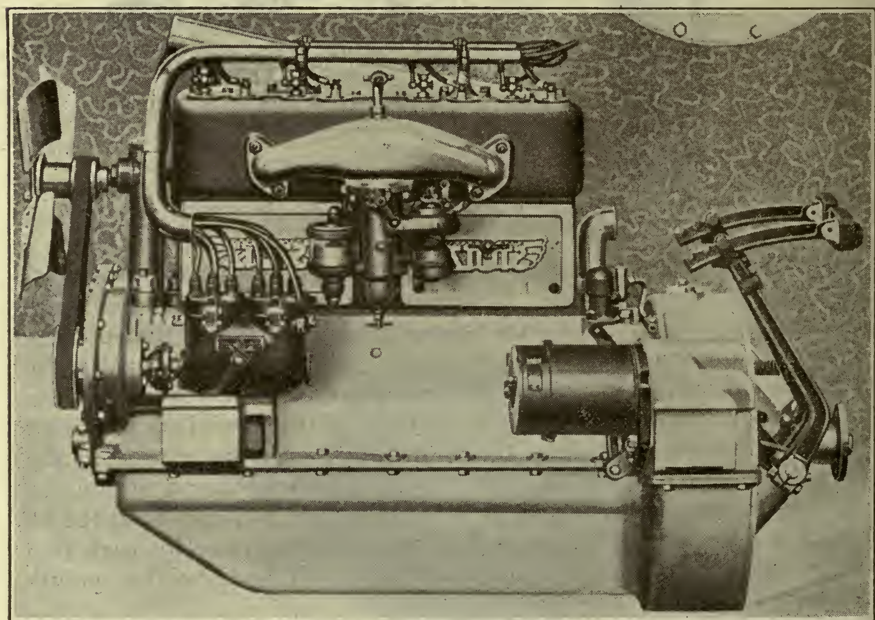


Fig. 373A. Stutz Engine with Double Distributor.

the cap. As far as the cap is concerned the sparks follow one another without any irregularity, but the cylinders may be fired in any one of several orders. All that is necessary is to find the proper lobe for

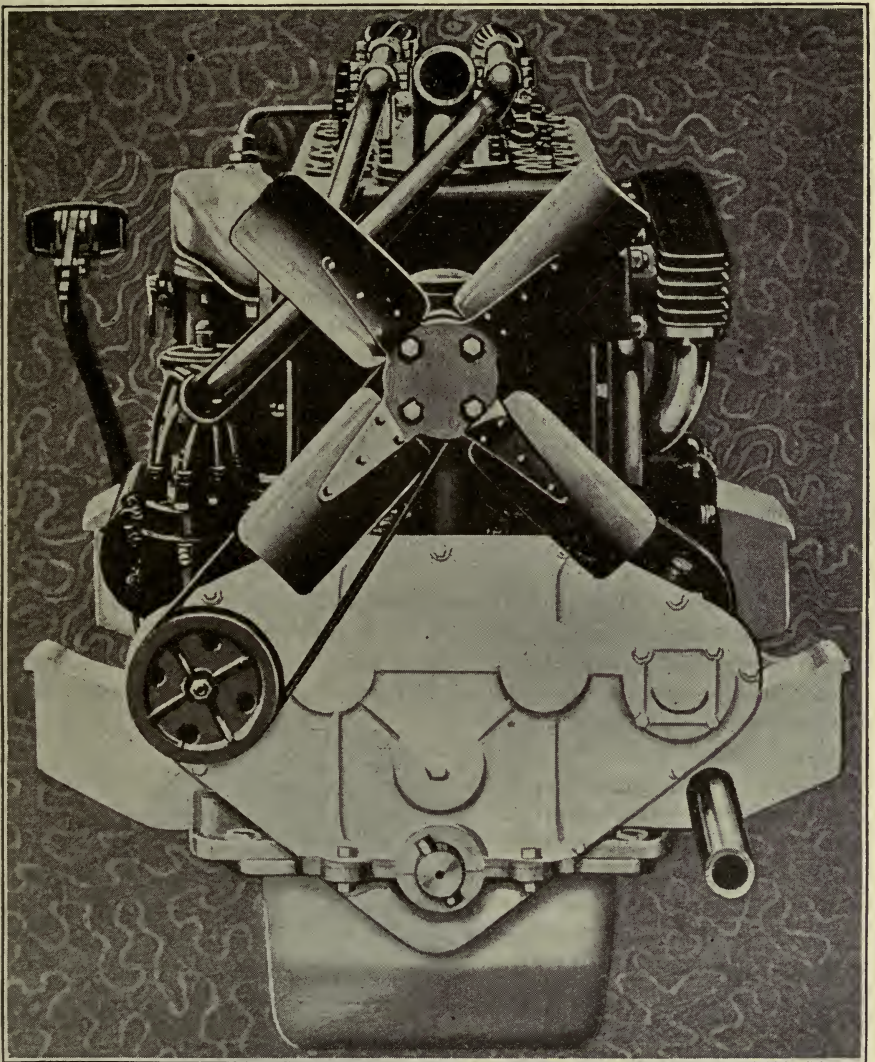


Fig. 373B. Stutz Engine with Double Distributor.

the first cylinder and then wire it accordingly. After that take the next wire from the cap to the next cylinder to fire, whichever it may be.

Spark Control.—On the speed of the engine depends to a certain

extent the point at which the spark should occur. By means of the spark manual on the steering column the distributor head may be swung through a short arc. This constitutes advancing or retarding the spark. In a motor running very rapidly the charge should be fired earlier than on the same motor running at a slower speed. This has relation to firing before, at, or after T. D. C., as explained in valve timing. In some cases the hand control is depended on altogether to control the spark advance. In other cases this is all con-controlled automatically, no hand control being provided, or a combination of the two is used.

Switches.—The make and break mechanism of the car has been compared to a switch, and such it is, but operated in fixed relation to the strokes of the motor. Unless the motor happens to stop with one of the lobes under the breaker point arm, thus holding the contacts apart, the current will continue to flow through the coil. The student will now grasp the need of the resistance unit being inserted in the primary circuit. If it were not for this unit and the current continued to flow, great damage would be certain to occur. With this measure of protection the greatest possible care should be used in all cases, when stopping the engine, to turn off the switch provided. This switch usually takes the form of a key arrangement on the dash used to make the primary circuit complete, or to break it when ignition is not desired.

Condensers.—In a general way the action of the condenser has been explained. As stated previously, a condenser is necessary for the proper performance of the ignition unit. The action of the condenser in the case of automotive ignition is as follows: The condenser serves two definite purposes. Current from the battery is always flowing through the ignition coil primary winding except when the points are separated by action of the cam lobes. Since this is a direct current flowing through the coil it tends to keep on flowing when the points are opening. This tendency to jump the gap would create quite a spark were it not for the condenser. The condenser is connected across the contact points. That is, a wire is run from one side of the condenser to one of the contact points, and another wire from the other side of the condenser

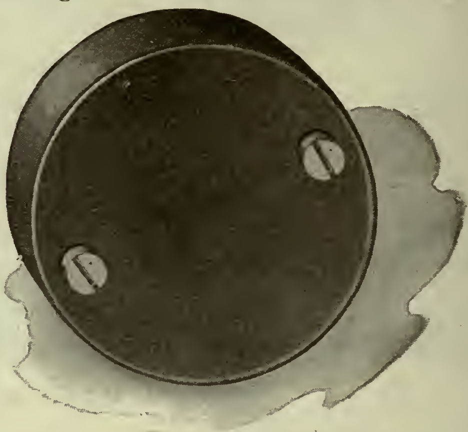


Fig. 374. Condenser mounted in case. (Wagner.)

to the other side of the contact mechanism. Now, when the points separate, the current, instead of flowing ahead and creating a spark as it attempts to jump the gap between the points, is sent into the condenser which acts as a storage reservoir. There is no electrical connection through a condenser when it is in good condition. If there is a circuit through it then the condenser is useless. As the points open and the current rushes into the condenser, one side of it is charged positively and one negatively at a rather high potential or voltage. This is due to the fact that as the points open the lines of force collapse, cutting the coil windings. These lines of force, which must collapse to give the spark at the spark plug, will also cut the primary winding and induce a rather high voltage in it. It is this induced voltage as well as the primary voltage which, failing to jump

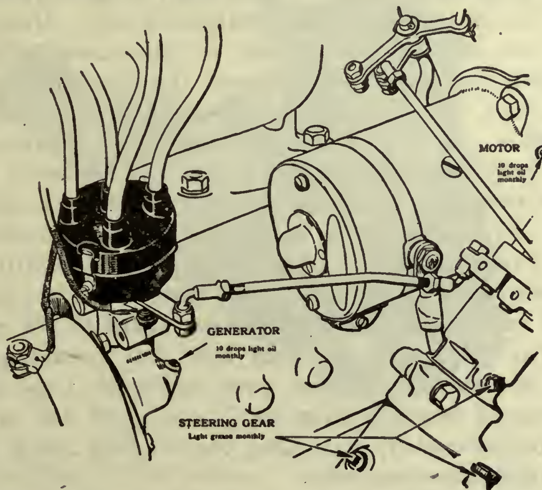


Fig. 375. Spark Controls, High Tension Cables from the Distributor and Oiling Directions. (Allen.)

the contact points, rushes into the condenser and charges it. The voltage of this charge is variously estimated at from 100 to 150 volts. This charge, however, does not remain within the condenser. The potential is high. There is a path open for it to discharge through. This path is back through the battery and the primary winding to the other side of the condenser. Consequently the condenser is no more than charged until it discharges back through the circuit including the primary winding of the coil with the very desirable result of causing the lines of force, which are collapsing about the core, to collapse very much faster. Since the voltage induced within the secondary winding is dependent on the rapidity with which these lines of force cut the many turns of the coil, the result is a very high tension current giving the desired spark at the plug. The student will want to understand that the difference of potential between the

two sides of the condenser is what causes it to discharge back through the circuit. In shop parlance the current is kicked back through. The current being kicked back through the circuit, which is in the reverse direction from the initial current, causing magnetism of the core, is a great help in completely demagnetizing the core, since it overcomes the residual magnetism and helps to quickly return the molecules to their original position within the core. This entire action following the opening of the points is instantaneous, the various steps following each other so closely that no time may be said to elapse between them. Reference to the illustrations will show methods and positions of condenser installation.

Spark Timing.—In most cases the timing of the spark to the engine is not a difficult matter where battery ignition is used. The first thing to do is to remove the distributor cap. Next remove the distributing arm and loosen the set or cap screw which appears. After this tightening device is loosened, the cam may be rotated on the stem, or shaft, in either direction desired by the operator, and as far as he desires. It is well to remember that a movement of a few degrees or a very small fraction of an inch is sufficient to adjust or put in time, unless the trouble is quite serious and the motor refuses to run at all. In a case of this nature it would be necessary to bring cylinder No. 1 onto the top dead center compression stroke, and then to set the distributor so that the rotor arm when in position would be so located as to bring the high tension spark to the wire running to cylinder No. 1 just as the cam lobe was breaking the points. Therefore, if the car on the road gave evidence of too great an advance, or appeared sluggish from too late a spark, the proper adjustment might be secured by loosening the binding screw and moving the cam as would seem necessary.

VIBRATION COIL IGNITION

Principle of Vibrator.—The vibrating coil is identical in construction with the non-vibrating coil, with this one exception. For

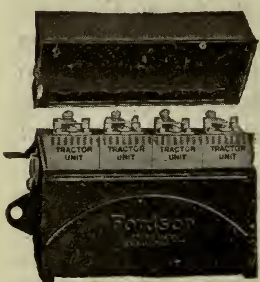


Fig. 376. Fordson Vibrating Coils. (K W Ignition Co.)

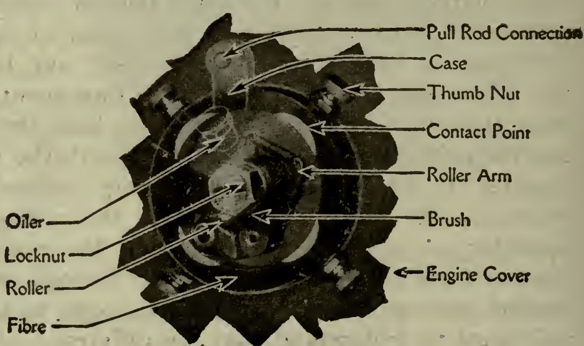


Fig. 377. Ford Timer.

the breaker points within the distributor head which are worked mechanically and in fixed relation to the firing order, the vibrating coil utilizes a vibrator mounted on the coil. The vibrator consists of a set of springs and conductors, and a set of contact points, frequently called vibrator points. When contact is made within the timer, which takes the place of the distributor, a primary current is sent through the primary winding of the coil. This causes a magnetic pull at the end of the iron core and thus attracts or pulls to it the steel spring on which is mounted one contact point. When this point is pulled away from the other, the primary circuit is broken or interrupted just as happened when the contact points were opened in the distributor head. The consequent action again is similar.

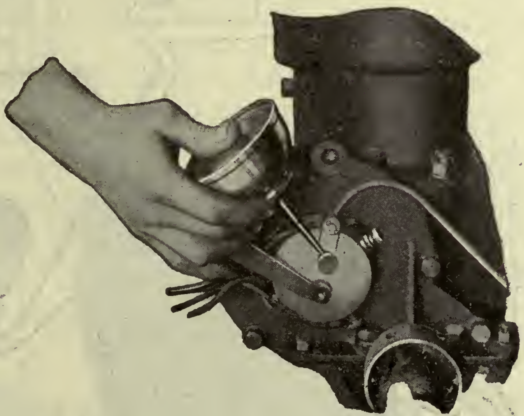


Fig. 378. Oiling Ford Timer.

That is, the breaking of the primary circuit causes the lines of force to collapse, inducing a high tension current in the secondary winding which is carried to the spark plug, there to ignite the fuel charge.

However, as soon as the magnetic effect of the iron core is broken down due to the breaking of the points, the cessation of primary current, and the condenser kicking back through the primary coil, the steel spring snaps the contact back in place, again permitting the primary current to flow. This again causes the contact to be broken, another induction of high tension current to take place, and another spark to be delivered to the same plug. These actions or operations follow each other so rapidly that there is what appears to be a continuous flow of high tension current jumping the spark plug points as long as the roller within the timer is in contact position. Since this system is that in use on the Ford car, the student is likely more or less familiar with it.

Timer.—A timer instead of a distributor is used. This is sometimes called the commutator. A roller with spring tension is mounted

on the cam shaft where it travels at one-half crank shaft speed. Within the timer head are mounted four (in the case of the Ford, this depends on the number of cylinders) strips of metal or contacts. The roller makes contact and electrical connection for the primary

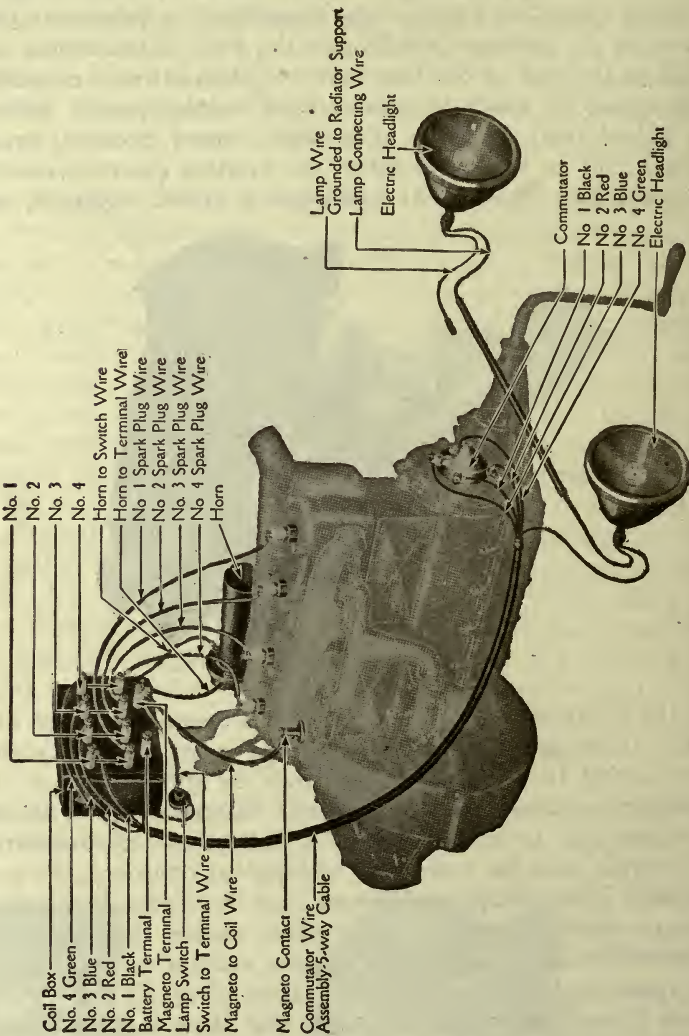


Fig. 379. Ford Vibrating Coil Ignition System.

current through these strips. Each timer contact is connected to a separate coil on the coil box carrying primary current from the magneto to it. As the roller rolls around on the inside of the timer head, one after the other of the coils are connected to it through the segments. As each one in turn is brought into action the high ten-

sion current is induced through the action explained above. Each coil is connected to one spark plug only. Whenever the roller is in contact, and for as long as it is in contact with its segment, that coil sends a spark to its plug. The essential difference between the vibrating and non-vibrating coils is that the last mentioned gives one pulse of high tension current to jump the spark plug points while the vibrating coil gives a series of pulses of high tension current to jump the plug points for each firing effort. In the case of the non-vibrating coil, the break of the contact points depends on the mechanical operation of the breaker points, a cylinder fired for each break. In the case of the vibrating coil the break of the points is entirely automatic, but at the same time this automatic action is controlled by the roller within the timer head.

Timing the Spark.—The timing of the spark as mentioned previously is largely dependent on the rolling of the roller within the timer, in relation to the cam shaft speed. Advance and retard of the spark are obtained from rotating the timer-head forth and back on its seat. Needless to state, the wires connected to the coils are made flexible and permitted to move with the timer-head.

As to the method of securing the spark in the proper cylinder: In this case the primary wires must be led from the timer to the proper coil to give the high tension spark in the desired cylinder. That is, coils and timer must be connected in relation to coils and cylinder. The whole must be in proper relation to timer roller and compression stroke.

Fig. 380. Atwater Kent Type "CC" Ignition Unit.

JOB 116. ATWATER KENT IGNITION SYSTEM, TYPE CC.

This system as used on the Maxwell car is of the closed circuit type differing radically from the K-2 system. The amount of current consumed for ignition is very much greater. Inasmuch, however, as the generator is producing current at all times this drain is not serious. The closed circuit system for battery ignition is used to such an extent that it might be said to be the standard battery system. The coil and the contact maker and distributor constitute the CC system.

Contact Maker.—The contact maker consists of an exceedingly light contact arm made from steel. The end of this arm rests lightly on the hardened steel cam which is driven at one-half crank shaft speed. The cam has four points opening the contact points four times for each two revolutions of the engine which is necessary for firing the four-cycle engine of four cylinders. Each time the points are opened the primary

circuit is broken, thereby inducing a high tension current in the secondary winding, which is led through the distributor to the spark plugs. The condenser is mounted directly on the contact maker. This construction tends to simplify the construction and increase the life of the contact points.

The high tension distributor forms the top of the instrument. The high tension rotor takes the jump spark current from the center terminal and distributes it to the plugs in proper firing order.

Coil.—This is of the usual non-vibrating type of construction. An iron core has two windings on it. The coarse winding or primary is next to the iron core. Over this are wound the many turns of fine insulated wire forming

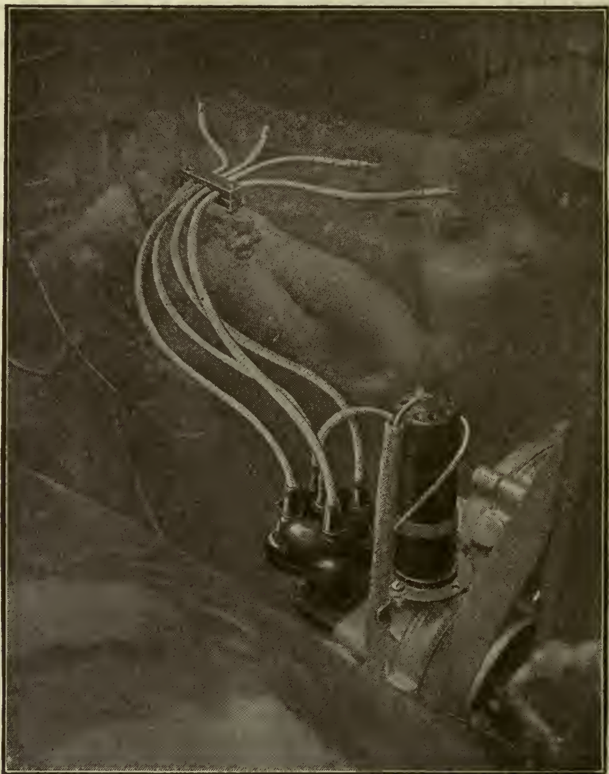


Fig. 381. Maxwell Atwater Kent Ignition System.

the secondary winding. The amount of current used is automatically regulated by the resistance unit in the top of the coil. The coil is carefully sealed to exclude moisture.

Setting and Timing the Type CC System.—First make certain that all advance rods and electrical connections are complete. Advance rods must be so adjusted that the full advance movement of the distributor is possible. With these precautions first taken, proceed as follows:

1. After wiring is complete remove the plugs and lay them on the cylinder head. Have the plug wires attached. Do not permit the terminal ends of the plug to touch the casting.

2. Turn on the ignition switch and crank the motor over slowly using the hand crank. Note that each of the plugs sparks in the proper firing order. For the Maxwell this is 1-3-4-2. When this is checked, turn off the ignition.

3. Set the spark lever on the steering wheel quadrant one and one-fourth inches from the full retard position.

4. Loosen the ignition coupling so that the knurled collar on the horizontal shaft may be easily turned.

5. With the hand crank turn the motor over until the piston in No. 1 cylinder is on exact T. D. C. between the compression and power strokes.

6. Turn the ignition on again.

7. With the fingers or the point of a screw driver move the knurled collar away from you or toward the engine, very slowly and carefully until a spark is seen to jump plug No. 1. Do this so carefully that the knurled collar stops the instant the spark occurs. If not certain of the operation, move the collar back one-quarter turn and try again.

8. Stop exactly as the spark occurs. Maintain the parts in this position until the adjustment can be secured by locking the hexagonal screw on the coupling clamp.

The motor is then timed so that the spark occurs on dead center when the spark lever is placed one and one-fourth inches from full retard. This allows of ten degrees retard for safe starting and about twenty degrees advance for high speeds.

Adjusting Contact Points.—If convinced beyond doubt that the contact points are at fault, they should be adjusted. The normal gap between the points should not be less than .005″ nor more than .008″. The standard setting is .006″.

The contact points are made from purest tungsten and are much harder than platinum iridium previously used.

JOB 117. ATWATER KENT IGNITION SYSTEM K-2.

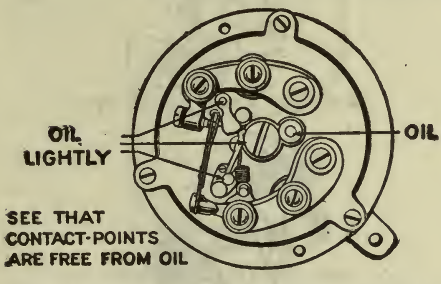


Fig. 382. View of contact maker showing places to be oiled.—Type K2.

In this system which operates on the open circuit principle there are three units. The Unisparker which combines the special form of contact maker which is the basic principle of this system, and the distributor for the high tension current. The **Coil**, which consists of the usual primary and secondary winding, is imbedded in a special insulating compound. The coil is of the non-vibrating type. The other unit is the ignition switch.

Principle of Operation.—The operation of the system is illustrated in Figs. 384, 385, 386, and 387. A notched shaft is provided, one notch for each cylinder. This shaft travels at one-half engine speed so as to provide the four sparks for each two revolutions of the engine. A lifter or trigger is operated by the rotation of the shaft being pulled forward. A spring attached to the trigger pulls it back to position. A hardened steel latch and a pair of contact points complete the instrument.

In Fig. 385 the lifter is being pulled forward by the notched shaft. When pulled forward as far as the shaft will carry it, the lifter is snapped back into its original position by the spring. In returning, it strikes against the latch throwing this against the contact spring, thus closing the contact points for a

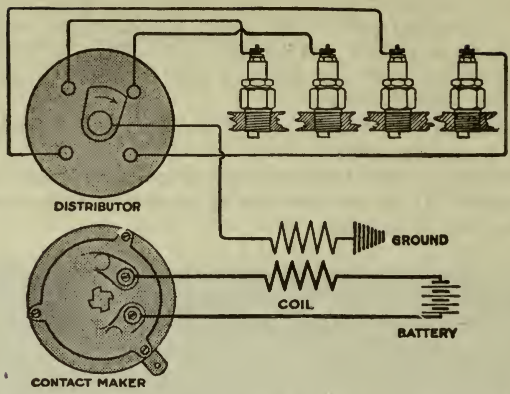


Fig. 383. Atwater Kent Wiring Diagram—Type K2.

very brief instant. The contact is made for such a small space of time that the eye cannot follow the action. This is quite different from the closed circuit type where the contact is made and considerable time is allowed for building up the magnetic field about the coil core.

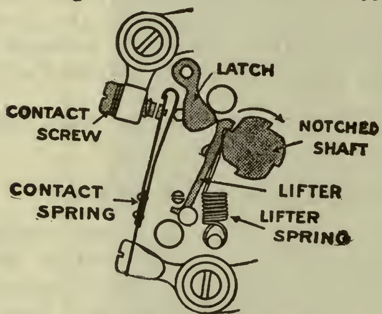


Fig. 384. Contact Open.

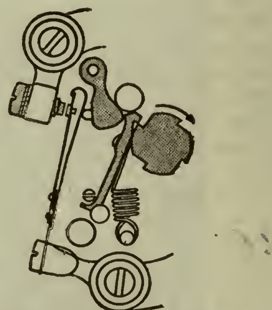


Fig. 385. Contact Still Open.

Fig. 386. Contact Made.

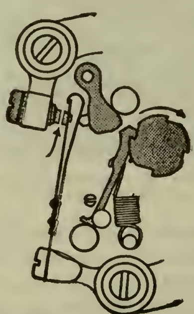


Fig. 387. Contact Broken.

In Fig. 387 the lifter has dropped into the second notch. The student will note that the circuit is closed only during the instant of the spark. No current will flow at any other time not even if the switch is left on with the motor standing idle.

The engine speed has nothing to do with the speed with which the contact is made and broken. No matter how fast the engine may be operating the

spring will always return the lifter at the same speed. This return speed is the vital factor in making and breaking the primary circuit.

Contact Points.—The contact points are the only parts adjustable and they require this at infrequent intervals. The normal gap is from .010″ to .012″, never closer. These points are made from pure tungsten. When working properly, small particles of tungsten will be carried from one point to the other, sometimes forming a roughness and dark gray color on the surface. This

Fig. 388. Wiring Diagram, Type "K-2" or "H", with Plate Switch or Kick Switch Coils.

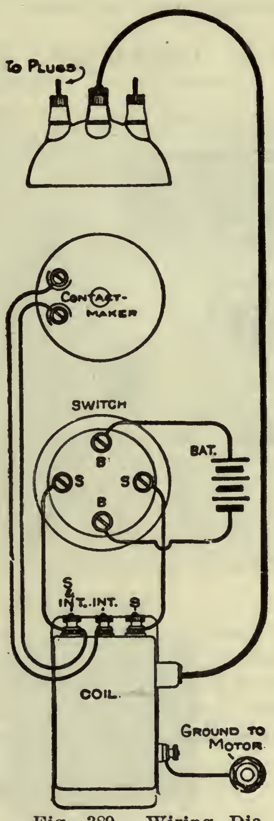


Fig. 389. Wiring Diagram, Type "K-2" or "H", with Underhood Coil Reversing Switch.

roughness does not in any way affect the working of the points owing to the fact that the rough surfaces fit into each other. However, if it becomes necessary to adjust the points the rough parts must be removed. To do this remove the contacts from the Unisparker and file the points with a fine file. When reassembled, the mechanic will want to see that the points have a proper bearing over their entire surface.

Oiling.—The other parts of the contact maker—the latch, the lifter, lifter spring and notched shaft are not subject to wear if they are properly cleaned and oiled at intervals of a few weeks. Under no circumstances permit oil to get on the contact points. Refer to Fig. 381 for oiling instructions.

Setting and Timing.—First put piston No. 1 on top dead center compression stroke. Loosen the clamp holding the Unisparker in position. Next turn the instrument backward, contrary to the direction of normal rotation, until a click is heard. This click occurs at the exact instant of the spark. Maintaining the Unisparker at this position it should again be secured by tightening the clamp.

The distributor cap is now removed and the terminal in contact with the distributor block is connected to cylinder No. 1. Connect the other cylinders in their proper order of firing.

JOB 118. NORTH EAST IGNITION SYSTEM FOR DODGE CARS. MODEL O.

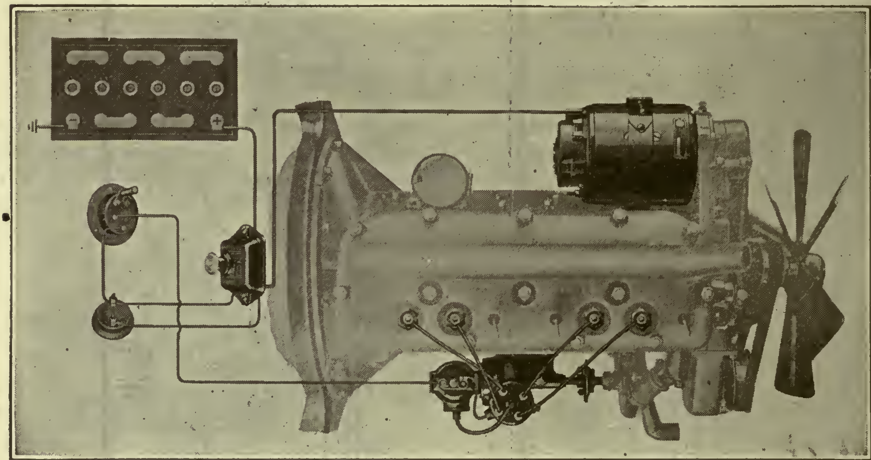


Fig. 390. Dodge North East Ignition System.

The ignition distributor is mounted on the right-hand side of the engine, being held in position by four bolts. There are two shafts, one a horizontal driven from the engine, and the other a vertical driven from the horizontal one. The latter is driven from the pump shaft through a flexible coupling. It is driven at engine speed. The vertical shaft travels just one-half as fast, the

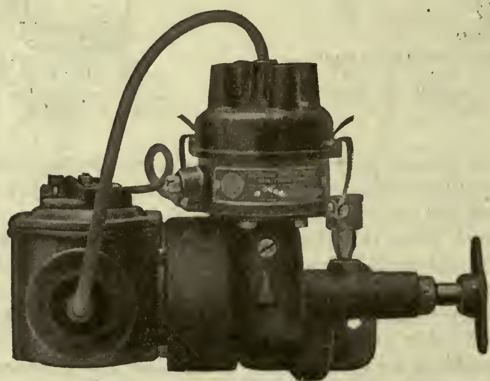


Fig. 391. Dodge North East Ignition System.

reduction of speed being through the spiral gears. The complete distributor unit consists of three self-contained assemblies. These are the ignition coil, the breaker box and distributor head assembly, and the distributor base assembly which includes the automatic spark advance mechanism. Any one of the three elements may be removed from the distributor unit without disturbing the other two.

Ignition Coil Assembly.—This is illustrated in Fig. 394. It is so constructed and designed as to operate on the twelve-volt starting and lighting circuit. The coil is not likely to cause any trouble and when this does occur the entire assembly is usually replaced. For tests on coils refer to Jobs 122 and 130.

Fig. 392. Breaker-Box and Distributor-Head Assembly.

Breaker Box and Distributor Head Assembly.—If for any reason the distributor head and breaker box is to be removed, first place the distributor in full retard position. Next remove the distributor head. Mark the exact position of the distributor rotor on the edge of the box. This mark should be made with special care, because it has to serve as the sole guide for the correct position of the vertical shaft when the assembly is put back in place on the distributor-base. Moreover, while the breaker-box assembly is separated from the base, the horizontal shaft in the base must not be turned from the position it occupied at the time when the location of the rotor was marked. If either of these precautions is neglected, the correct relationship between the several moving parts of the system will very probably be disturbed to such an extent that a complete retiming of the distributor will become necessary.

The breaker box contains the condenser as well as the breaker contacts and breaker cam. The distributor head covers the entire box excluding water, oil and dirt.

Fig. 393. Distributor-Head.

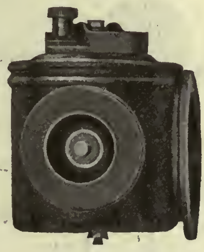


Fig. 394. Ignition Coil Assembly.

Breaker Contacts.—The breaker arm carrying one of the breaker contacts is mounted on a pivot from which it is thoroughly insulated by a fiber bushing. The coil spring, which is attached to the lug at the pivot end of the arm, holds it in such position as to keep the points closed, making the system a closed circuit system. The fiber block mounted near the center of the breaker arm is struck by each lobe on the breaker cam, in turn, and the points are separated. This produces the four interruptions of the primary circuit necessary to the production of the four high tension sparks, for each two revolutions of the engine.

The second contact is carried by the stationary contact stud which is adjustably mounted in an arched support. With this stud properly adjusted,

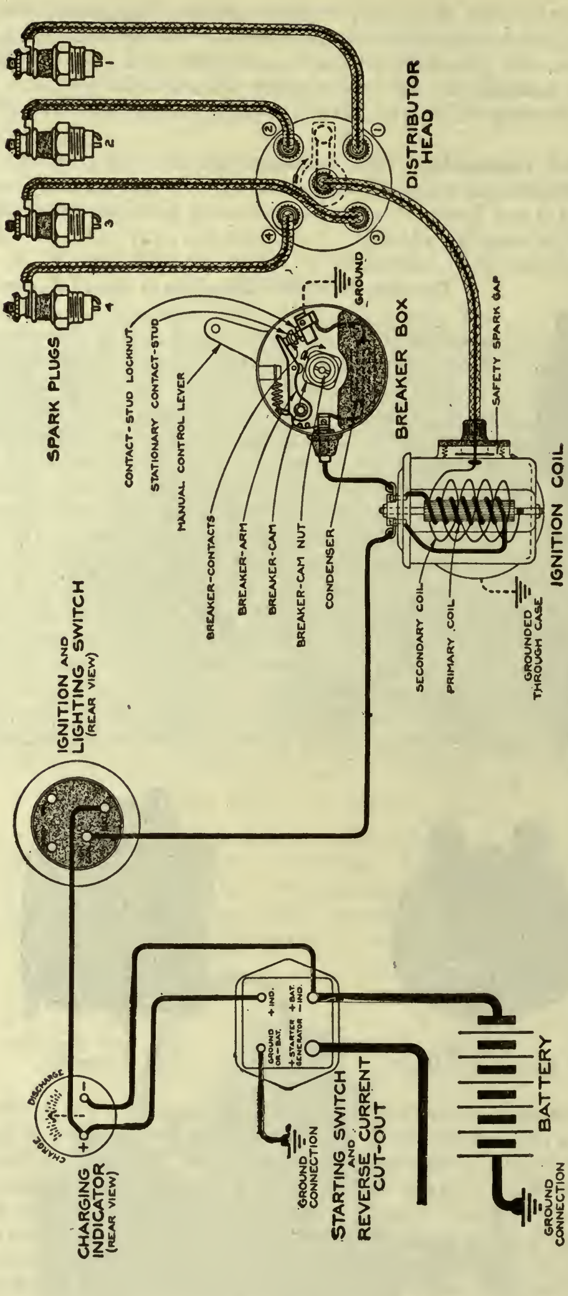


Fig. 395. Circuit Diagram of the Model O Ignition System on the Dodge Brothers Motor Car. Type 10004 Distributor Unit—Ground Return.

the distance between the contact points when they are fully separated by the cam is .020″.

Replacement of Breaker Contacts.—The proper method is to replace the

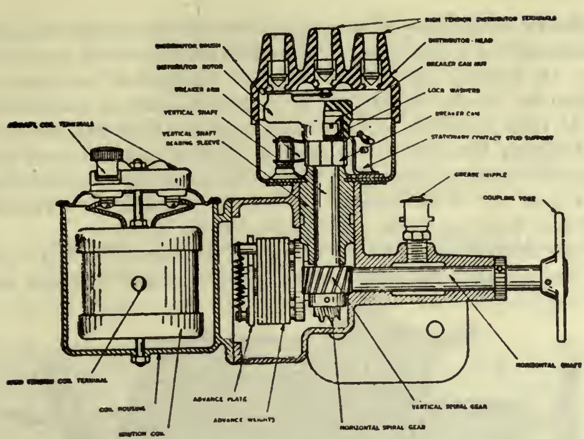


Fig. 396. Model O Ignition Distributor.

entire breaker arm and stationary stud assemblies. The breaker arm can be removed by simply lifting it off its pivot after its pigtail has been disconnected from the breaker-box binding post. The spring attached will slip off of its own accord as soon as the arm is raised sufficiently from its normal position. After the breaker arm has been taken off, the stationary contact stud can be removed by releasing its lock nut and unscrewing it from its support. Reverse the operations to replace.

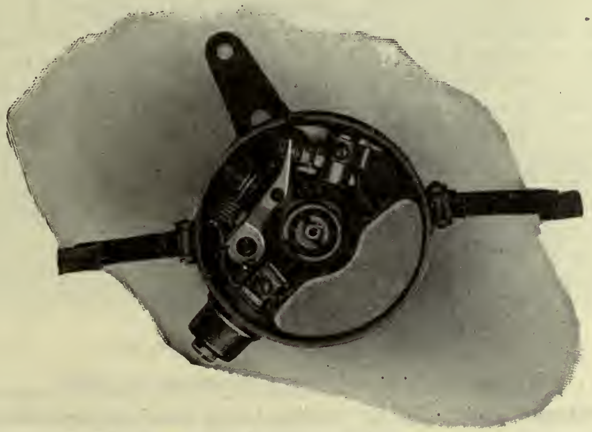


Fig. 397. Breaker-Box.

Automatic Spark Advance.—Combustion does not follow instantaneously on the occurrence of the spark, however, because a small interval of time is always needed for the gas in the cylinder to ignite. Consequently, unless some means were provided for offsetting the lag between the spark and combustion, the explosion of gas could not always be made to take place at the right moment under the varying speeds of the motor. The centrifugally actuated mechanism shown in Fig. 399 is designed to care for this by automatically advancing and retarding the time of the spark in exact accordance with the speed at which the engine is running.

Manual Spark Control.—This works independent of the centrifugal device. It is used principally for starting or idling the engine, or to facilitate carburetor adjustments. In normal driving the correct method of use is to advance the manual control as far as the engine will permit without knocking and permit it to remain at that position. The actual regulation of the advance and retard is then cared for by the automatic device. When properly set with reference to the cam position the retarding of the spark lever permits the spark to occur eight degrees past top dead center. With the spark lever advanced the spark will occur fifteen degrees before top dead center.

Timing the Distributor.—First bring the piston in No. 1 cylinder to top dead center, and advance the hand crank carefully until it is just starting down.

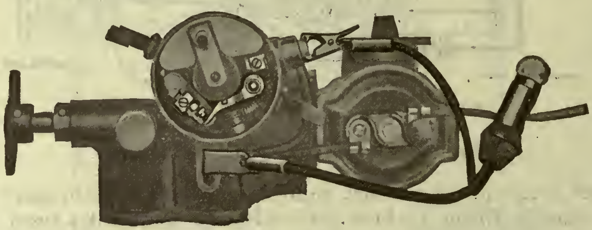


Fig. 398. Ignition Distributor with Test Lamp Attached—Ground Return System. Rotor in position for Spark to occur in No. 1 Cylinder.

To be certain of this it is best to do the work with the cylinder head removed. The mechanic may use some method which does not require the removal of the head but should be certain that the position is correct. Next, remove the control from the breaker-box arm and retard it fully by moving it as far as it will go in the direction of rotation of the vertical shaft. With the ignition switch in off position, the distributor head and distributor rotor may be removed. The breaker-cam nut may be backed off by means of a screw driver with a blade wide enough to catch both sides of the nut at one time. This will leave the cam free to rotate on its shaft. Next replace rotor and turn the cam slowly until the breaker points just begin to open when the rotor occupies the position where it normally makes contact with the No. 1 distributor terminal. Refer to Fig. 398 which shows the distributor and rotor in this position.

Fig. 399. Automatic Advance Mechanism on Shaft.

This adjustment can often be facilitated by turning the cam forward to separate the contacts, and then back again slowly until the contacts just come together, at which point the cam should be allowed to remain. When the proper position for the cam is assured the rotor should be removed again and the cam locked in position by tightening the slotted nut which holds it. Replace the rotor and rock the vertical shaft back and forth as far as the slack in the gears will permit, noting carefully the action of the breaker contacts. The setting must be so accurate that as the gears are rocked forward to take up the slack the contacts will just separate, and yet when the gears are rocked backward the points will actually close.

Using Lamp Bulb to Check Timing.—A convenient method of verifying the ignition timing is to use a twelve to sixteen volt bulb connected as shown in the illustration, Fig. 398. When the contacts separate, the bulb will light. When

the contacts are closed the current all passes through the ignition unit and the lamp does not light. The instant of opening and closing of the points is very evident as indicated in the bulb. This test may be applied to any battery system if care is used in selecting the correct size of bulb and the points of connecting the wires to put it into circuit across the contact points. In general it might be said that when a grounded return is used one cable is grounded, while where a two-wire or insulated return is used the proper terminals must be located and used.

JOB 119. HUDSON DELCO IGNITION.

The ignition unit is located above the timing gears of the Super Six motor. It is driven by spiral gears from the pump shaft. The distributor head is of

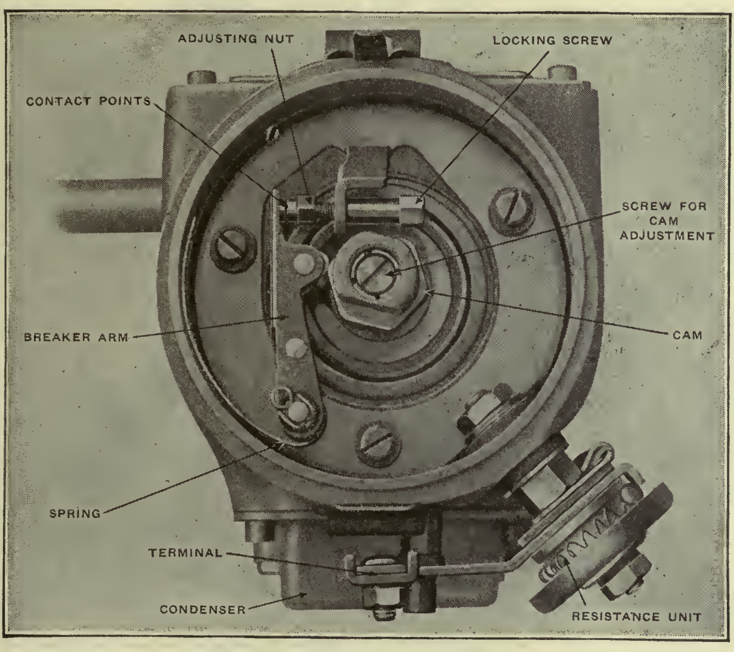


Fig. 400. Hudson Delco Distributor.

the usual constant contact type. Beneath the distributor head and rotor is the timer. By loosening the screw in the center of the shaft it is possible to time the ignition. By moving the cam in a clockwise direction the timing is advanced, and by moving the cam in a counter-clockwise direction the spark is retarded.

The proper gap for the contact points is .018". If it should be necessary to clean the contact points use a strip of fine sandpaper pinched between the points.

A top view of the timer mechanism is shown in Fig. 400. In this figure the rotor and the distributor head are removed.

A side view of the unit is shown in Fig. 401. Note the automatic spark advance.

Timing and Ignition.—Set the spark lever on the steering wheel at the top, making certain that all parts are in proper working condition for full movement of the advance and retard mechanism as effected manually.

Open the priming cocks and set piston No. 1 on top dead center of the compression stroke.

No. 1 cylinder is due to fire in advance position when the mark A on the flywheel reaches the pointer attached to the crank case. This may be observed through the inspection hole on the flywheel housing, left side motor. Mark "A" is one-half inch before top dead center. Top dead center is marked D. C. 1 and 6.

Loosen cam and set to break at this point. Make certain that the adjusting screw is set properly so as to prevent a change in timing.

The spark occurs the instant the contact points open. In checking the timing hold the cam on tension in the opposite direction of rotation in order that all backlash be removed from the gears.

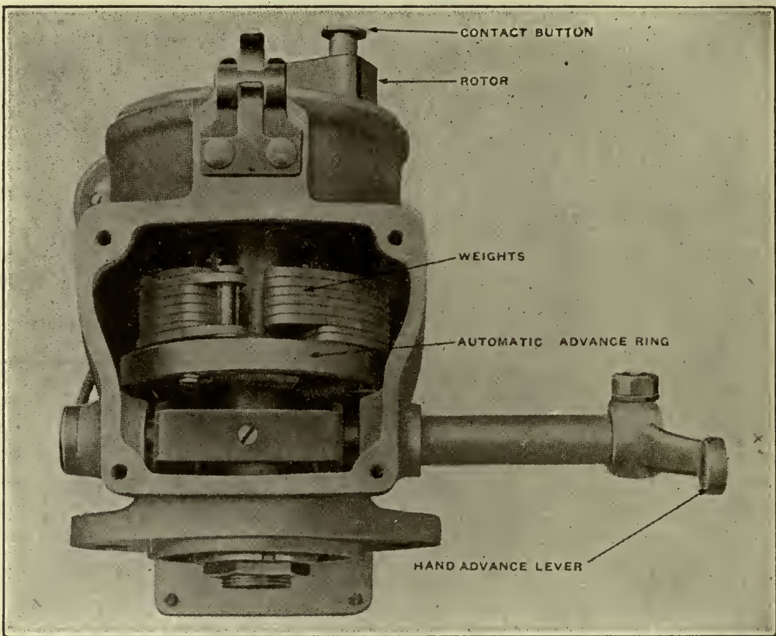


Fig. 401. Hudson Delco Automatic Advance Mechanism.

After retiming and rechecking the timing of the opening of the breaker points, the head may be replaced. Place a bit of vaseline on the rotor track so that no wear may occur.

Coil.—The coil is of the usual non-vibrating high tension induction type. It is mounted on the dash.

JOB 120. BUICK DELCO IGNITION.

The distributor timer is mounted on the front end of the motor generator. It is driven by a spiral gear which is cut in the outer face of the generator driving clutch. The driving gear is operated by the pump shaft at one and one-half times engine speed. This in turn drives the vertical shaft of the distributor at one-half engine speed. The vertical shaft carries the breaker cam, the rotor, and the automatic advance mechanism.

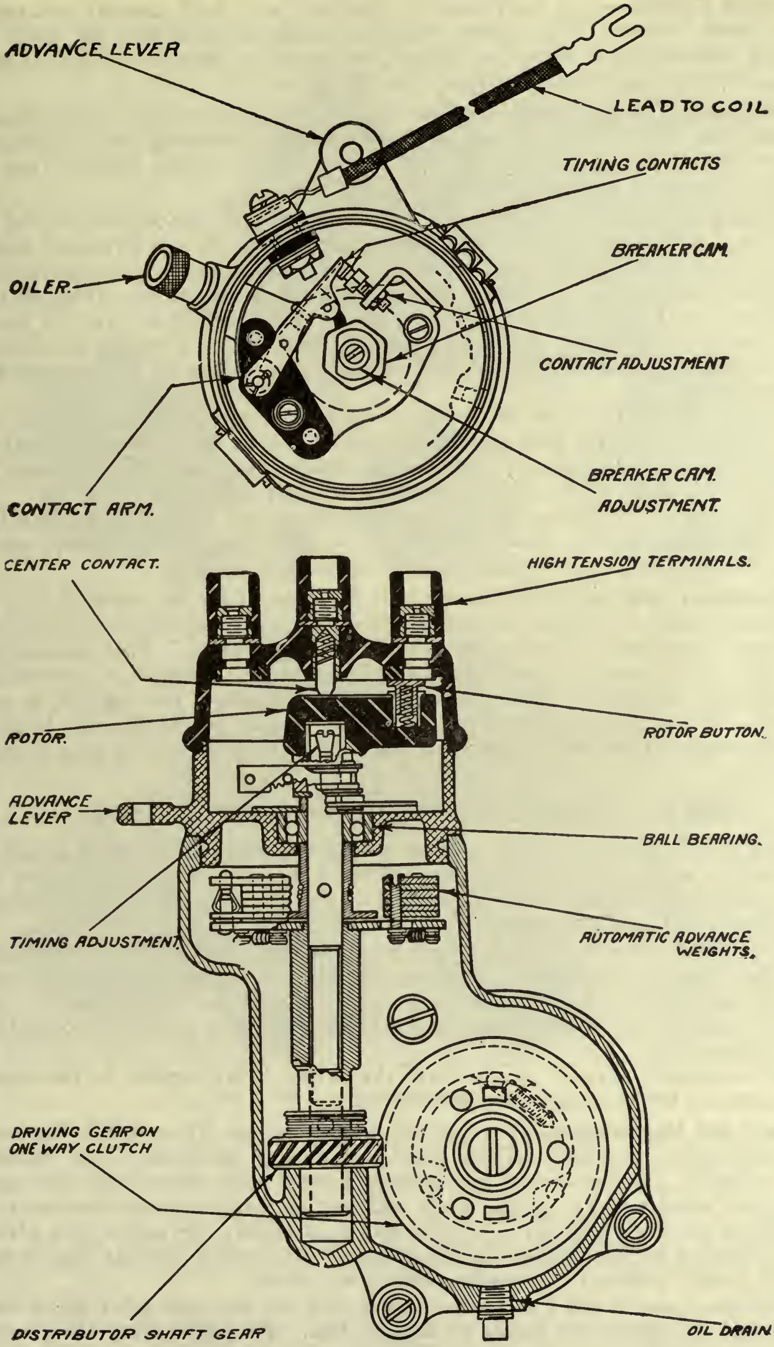


Fig. 402. Buick Delco Ignition Unit.

Spark Control.—The distributor is equipped with both manual and automatic spark control. The manual control is used for retarding the spark in starting and very slow idling, as well as the necessary advance for low engine speeds when the automatic advance is not operative.

Adjusting Timing Contacts.—The contact points when fully open should measure just .018″. The adjustment is effected by loosening the adjustment nut and screw shown in the top of Fig. 402. Make certain the lock nut is properly tightened after adjustment is completed.

Timing the Ignition.—First place the spark lever on the steering wheel in the fully retarded position. Next turn the engine to the seven-degree mark which is practically one inch after top dead center with engine on compression stroke for cylinder No. 1. The timing adjustment screw in the center of the distributor shaft is loosened and the breaker cam is turned so that the rotor button will be in position under high tension terminal No.1 when the distributor head is properly located. This determines the proper lobe of the cam to use for timing.

In attempting to locate the point at which the cam must be set use the following plan. Set the cam so that when the slack in the distributor gears is rocked forward the contacts just open. When the slack in the gears is removed by rocking backward the contacts will just close.

Tighten the adjustment screw with the parts in this position. Replace the rotor and the head. The firing order is 1-4-2-6-3-5. Test all high tension wires to see that the proper wire leads to each cylinder in turn.

Resistance Unit.—The resistance unit is mounted on the forward end of the ignition coil. It consists of a special resistance wire wound on a porcelain spool and connected in series with the primary winding. This connection appears in the circuit diagram Fig. 395. It serves the purpose of preventing an excessive discharge from the storage battery when the engine is not running, and the ignition switch is on with the contact points closed. It also, through current regulation, insures a more even spark at the varying engine speeds.

JOB 121. PIERCE ARROW DOUBLE DISTRIBUTOR.

The Pierce Arrow car uses a T head motor and provides double ignition. The ignition switch is so arranged that either double or single ignition may be used at the option of the driver. Two sets of plugs, condensers, breaker points, transformer coils, etc., are used.

The double system is used except when testing one system independent from the other or when the battery may be very low. The idea of the double ignition application to the Pierce engine is to have the charge within the cylinder fired at two points simultaneously thus insuring rapid and complete flame propagation.

An automatic advance is provided, the action being similar to the automatic advance for the single distributor head.

Care and Maintenance.—The battery breaker points KL and EP, Fig. 403, should be set to open .015″. These points are of pure tungsten. They require little attention. If they do not give perfect contact after adjustment they may be put into service and in a little while will true themselves up as they wear.

Before putting a new car in service, and occasionally thereafter, it is advisable to place a bit of vaseline on the track of the contact buttons within the bakelite head. Remove any surplus with a dry cloth.

The fiber cams F and J will wear a bit during the first 1000 miles and it may be necesary to adjust the points to remedy this. Thereafter very little wear will occur at this point.

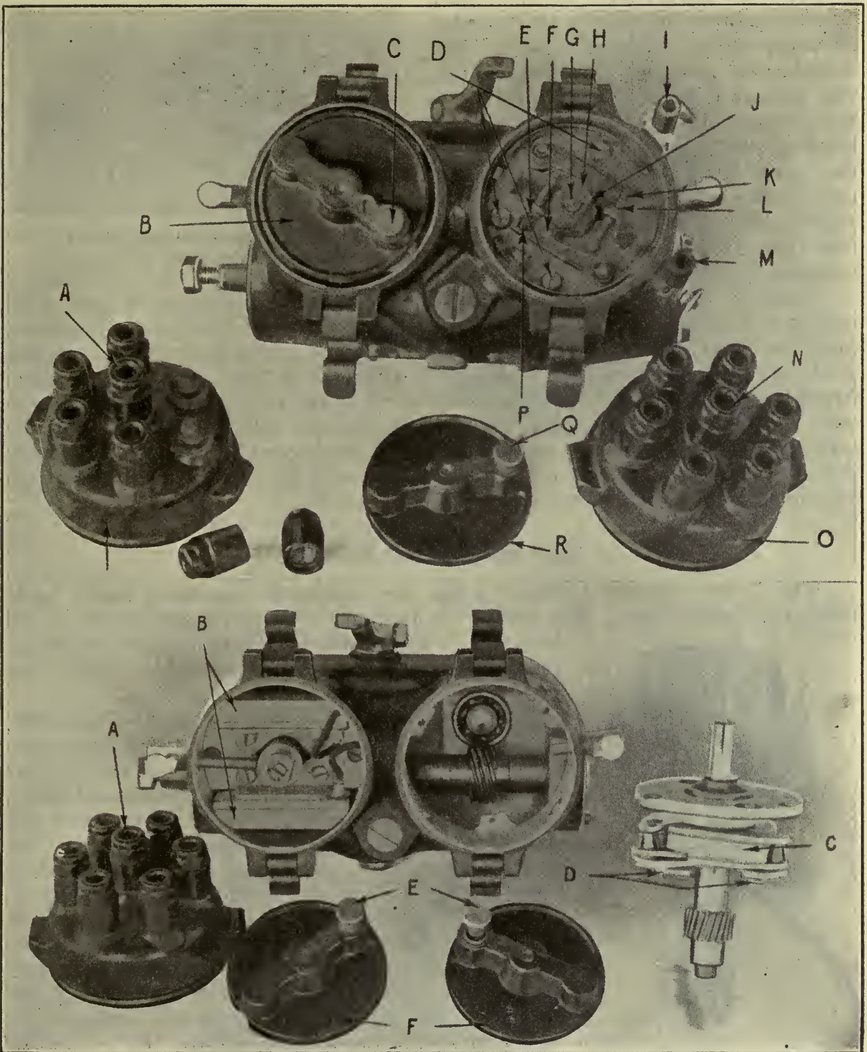


Fig. 403. Pierce Arrow Double Distributor (Delco).

If it is desired to make the points open a bit nearer exact synchronism it can be accomplished by loosening the screws D, D, and D, Fig. 403, on the sub-base to which the breaker mechanism is attached. The equalization is then effected by moving the sub-base about until the desired result is obtained.

It may be noted by examining the bakelite distributor tops or heads that the firing order is imprinted on them, with the proper cylinder number opposite each terminal.

Timing the Spark.—For timing this double ignition unit to the engine, first place the flywheel so that the indicator is over the ignition mark on the

flywheel as shown in Fig. 404, being careful to have the engine on the compression stroke for cylinder No. 1. The distributing arms in the Delco Unit, Fig. 403, should then be in position to fire cylinder No. 1, as marked on the head of the distributing units. With the spark fully retarded on the quadrant, both sets of points should just be on the point of opening. In this position the distributing unit should be connected to the driving flange on the pump shaft.

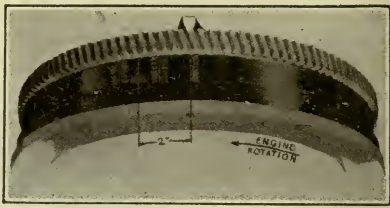


Fig. 404. Pierce Arrow Timing Diagram.

To make a slight adjustment of the timing, to make the points open a bit earlier or a bit later, the instrument is not disconnected from the pump shaft coupling, adjustment being made by loosening the adjusting screw G instead. With this screw loosened the cam may be adjusted to make the points break at the proper time. Care should be used to see that the cam is not moved through more than a very slight angle. If it is moved any considerable amount, the spark timing will be out very much. It is quite possible to move the cam until the break occurs, when the distributing arm or rotor is under the high tension wire leading to some other than cylinder No. 1.

JOB 122. REMY IGNITION.

The Remy Battery Ignition Units are standard equipment for a large number of motor cars. The matter of care and adjustment is similar for all motors. Where possible, the instruction book for the particular model being worked on should be consulted.

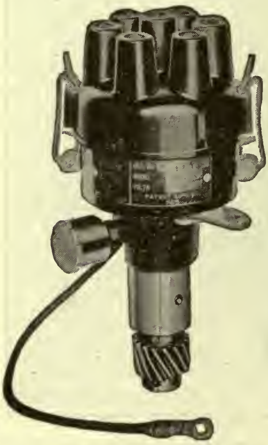


Fig. 405. Remy Ignition Distributor.

Contact Points.—The points should be inspected regularly each 1000 miles to see that they are maintained in good condition. If they show signs of uneven wear fold a strip of OO sandpaper and place same between the points in such manner that the sanded surfaces are in contact with the points. By working this forth and back between the points they may be cleaned and any irregularities overcome.

The points should be maintained with a break of .020″ to .025″. To adjust the gap loosen the lock nut next to the post and turn the contact screw until proper clearance or gap is obtained. Lock the nut on the screw to maintain the setting.

Timing to the Engine.—Place the piston in cylinder No. 1 on top dead center. This may be accomplished through the aid of a gauge in the spark plug hole or by noting the fly wheel marking where such is given. Work with the piston on compression stroke.

Place the distributor advance lever on full retard. Remove the distributor cap. Remove the rotor or distributing segment. This lifts up. Unscrew and remove the nut appearing. Next loosen the cam from the taper on which it is fitted. Use a screwdriver to pry up on it, rapping it lightly at the same time. Use care to prevent damage to any of the parts.

The cam may now be reset by moving it in the direction in which it rotates until the points are just opening, the engine being maintained in the position noted above. Since the spark occurs just as the points separate, it will occur

with this setting at exact top dead center. It is safe to have the piston in cylinder No. 1 just a bit over top dead center on the power stroke since the spark control is fully retarded.

Advancing the spark with this setting will give the required range for efficient engine operation.

The distributor rotor may now be replaced and the distributor cap likewise. The high tension cable leading to cylinder No. 1 must be that one which attaches to the distributor cap terminal immediately over the rotor within the head, since it is to that terminal high tension spark will be conducted when the points break.

The other cables must be led from the distributor cap in order, but run to the cylinders in their proper firing order.

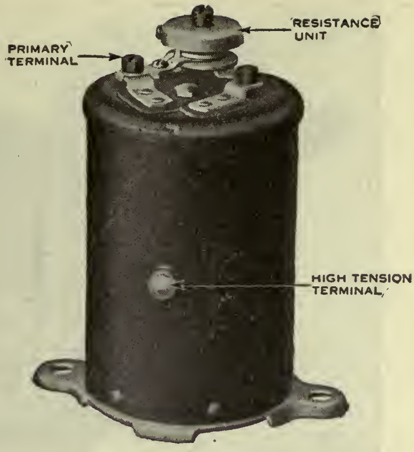


Fig. 406. Remy Coil Assembled.

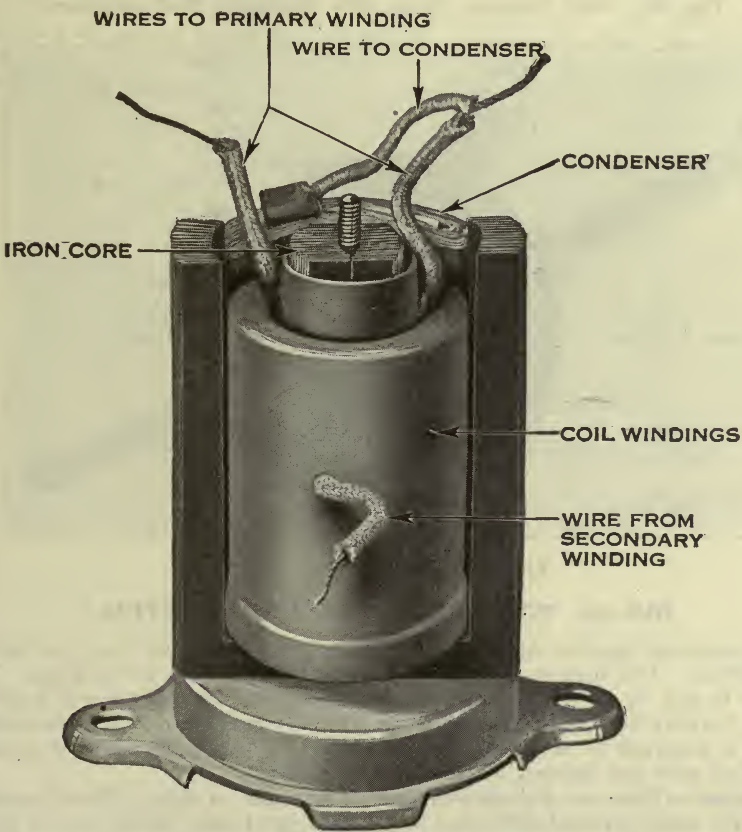


Fig. 407. Details of Remy Coil Construction.

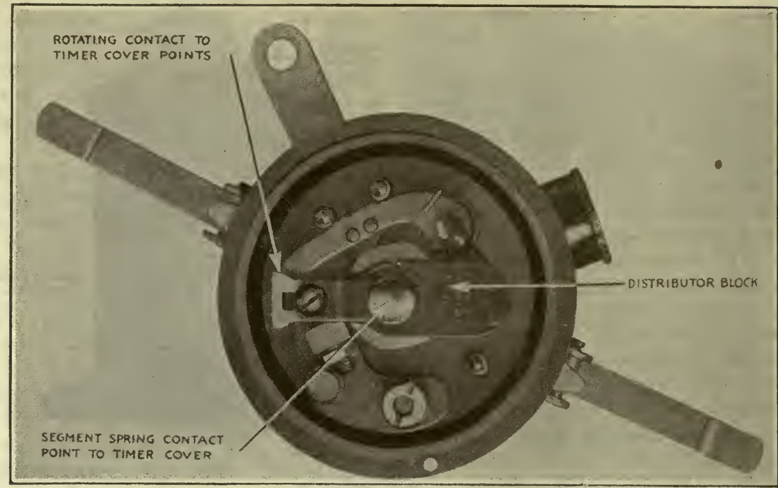


Fig. 408. Remy Chalmers Timer with Distributor Block in Place.

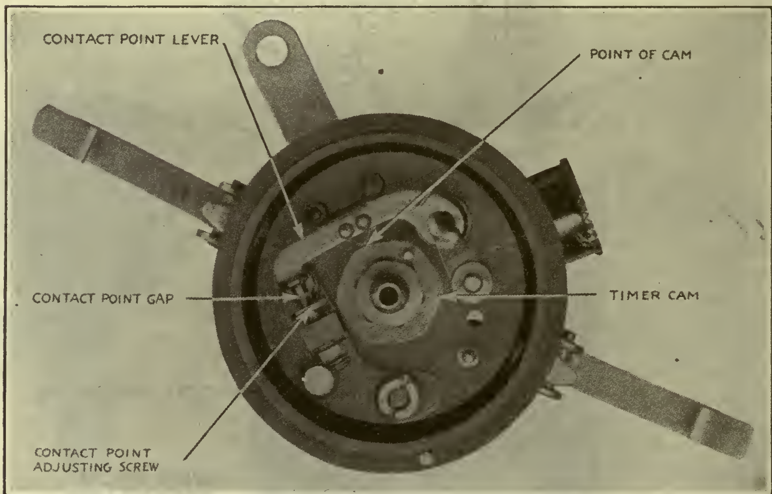
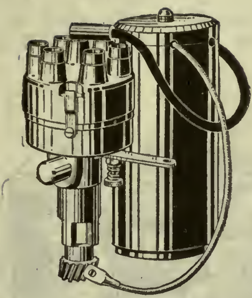


Fig. 409. Remy Chalmers Timer.

JOB 123. CONNECTICUT IGNITION SYSTEM.

Connecticut ignition apparatus uses unrestricted current from the battery for ignition. This insures a good spark at all times for use at the plugs. The system is able to use this flow of current without danger of battery drainage or coil burning because of its automatic switch arrangement. A thermostatic device is arranged to break the circuit in the event that the motor is stopped or stalled with the ignition left on.

Igniter.—These are provided for use on four, six, or eight-cylinder engines. The main constructional difference is the number of cams milled on the upper end of shaft A, Fig. 412, which shows the working parts of the igniter. Fig.



No. 410. Connecticut Coil and Igniter.

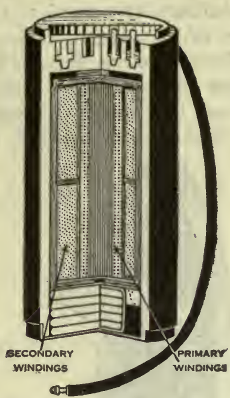


Fig. 411. Section Connecticut Coil.

410 shows an external view of the Igniter and Coil. Fig. 411 shows a sectional view of the Connecticut coil.

In Fig. 412 the shaft A extends through the instrument. The lower end is driven from the engine at the required speed. The cams B, milled on the upper end, operate the breaker arm C and point E which it carries. G is a roller on which the cams operate the arm. The point E operates in conjunction with point F. The spring H returns the point E and arm C to position after the cam passes the roller.

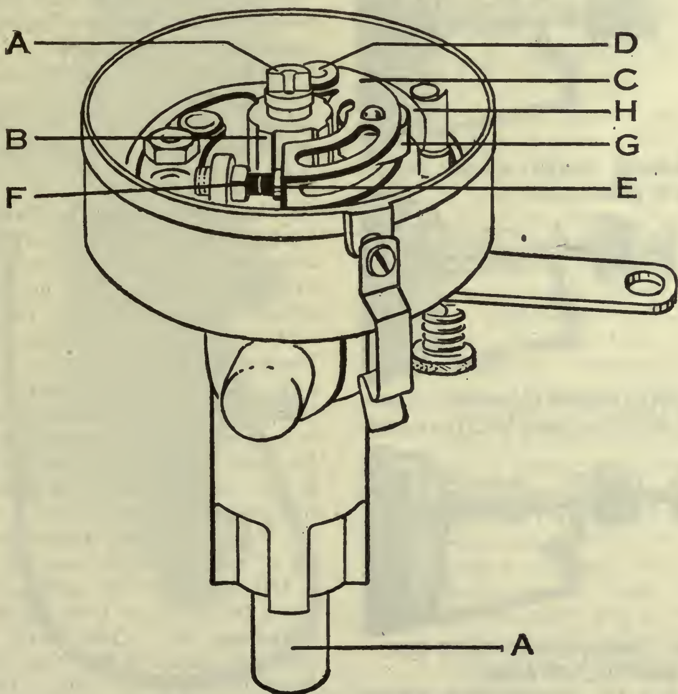


Fig. 412. Connecticut Igniter with distributor cap removed.

It is during the period of contact between the points E and F that the coil saturation takes place. The more complete the saturation, the better the spark.. The system is designed to give all the time possible for this operation.

Breaker Points.—The breaker mechanism of this igniter is very easily removed and replaced. It was so designed to enable the user to make a complete replacement should there be occasion to do so. It will be found advisable to replace the complete breaker plate rather than individual points. The successful operation of the coil will be hindered by any irregularities of the point adjustment and in time this may do serious ininjury. Unless the points are properly adjusted, arcing and burning is bound to occur.

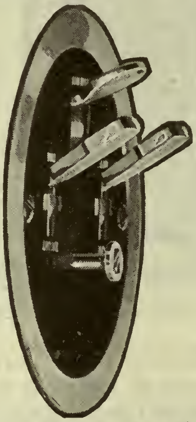


Fig. 413. Connecticut Toggle Switch.

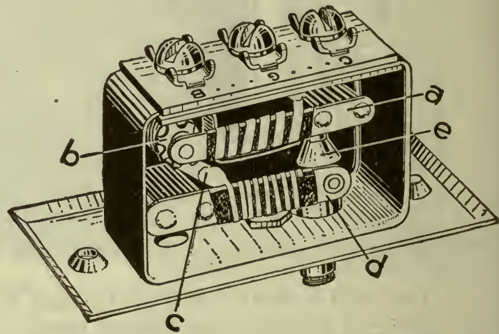


Fig. 414. Connecticut Automatic Kick-off unit as used with Connecticut switches.

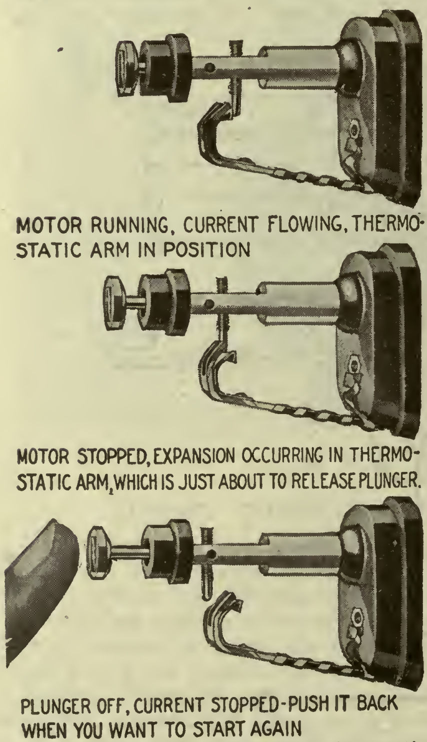


Fig. 415. Connecticut Automatic kick-off device.

Automatic Switch Feature. — Connecticut switches incorporate an automatic cut-out feature in the various designs. The principle of operation is the same for the several styles of switches. In fact, the part known as the K unit is designed into switches of several different types. The latest Connecticut switch is operated on the toggle principle. In this switch, too, the automatic device is differently designed, but the principle is the same.

To secure the automatic kick-off of the current in case the engine is left idle with the ignition switch on, a thermostatic principle is taken advantage of. One form of the device is shown in Fig. 414. Another form is shown in Fig. 415. The action is as follows:

As soon as the motor stops running and the interruptions of the ignition circuit cease, the flow of current increases and heats up the wire ribbon about the arm A, Fig. 414. This arm is so constructed that when heated it bends down until it makes contact with post B. The current then flows down post B through the wire which connects B and C, up C into the ribbon around D. Arm D is constructed similarly to A, but is arranged to bend upward when

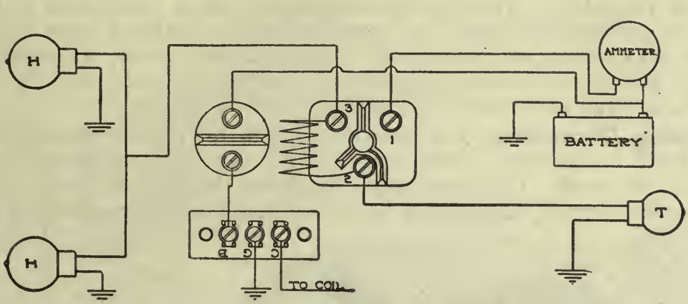


Fig. 416. Connecticut Switch and Igniter Wiring Diagram.

heated. This upward bend or movement releases the latch which holds the plunger E in the "On" position, causing it to kick out and break the ignition circuit. It requires a short interval of time for this action to take place so that it does not interfere with the normal duties of the system, but does protect the battery and coil when the ignition is on and the engine idle.

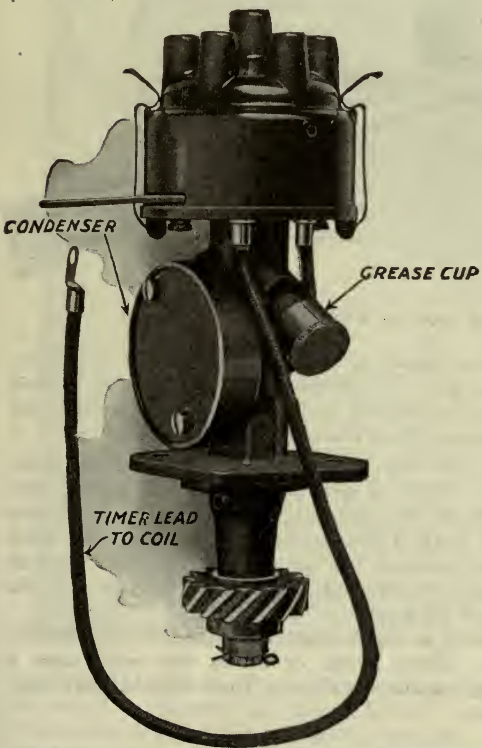


Fig. 417. Complete Wagner Timer Distributor.

JOB 124. WAGNER IGNITION.

The Wagner ignition is designed to give a hot spark for low speeds and at the same time to efficiently take care of the maximum speed of which the engine is capable. The timer distributor and coil are both dust and waterproof.

Coil.—The coil is of the non-vibrating type. It is enclosed in a hermetically sealed case, thus protecting it from moisture or mechanical injury. The coil illustrated in Fig. 420 has a safety spark gap incorporated in it. This gap serves to protect the coil from excessive electrical strains in event of failure of some other part of the high tension circuit. The action of the spark gap as the current crosses it in such a case will be noticeable through the mica window.

The internal arrangement of the Wagner coil is different from other coils. The high tension current is brought out in the center at the top, through a bakelite insulator which is molded into the steel case. This construction makes the case very sturdy. The construction of the coil case helps to prevent injury to the windings and misfiring during wet weather.

Distributor Head.—The Wagner timer distributor is shown in Fig. 417 completely assembled. The system will operate over a wide range of battery voltage. A satisfactory spark for ignition can be obtained even when the battery is too low to crank the engine. Starting in this case is effected by hand cranking. The cover for the distributor is molded from bakelite. When the high tension wires are properly assembled the head is water-proof.

Revolving Distributor.—The revolving distributor carries the high tension current from the center of the cover to the terminal connected with the cylinder to be fired. The metal plate carrying the current does not make actual contact with the distributing pins, but passes within ten-thousandths of

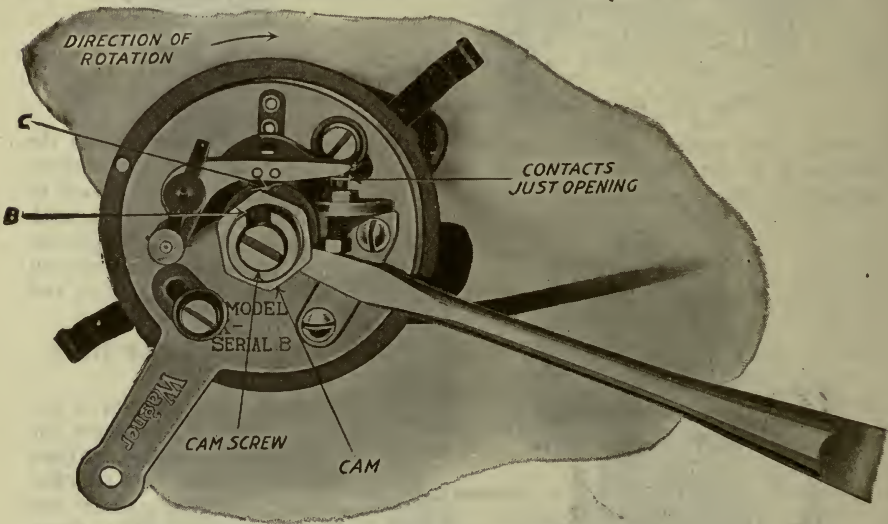


Fig. 418. Setting cam on Wagner Head.

an inch of them, thus permitting the spark to jump to the pins in the same manner as the spark jumps the plug gap. A special grade of tungsten is used for the contact points. It requires no cleaning or filing, and will operate best if left entirely alone until the tungsten is nearly worn away.

Fitting New Contacts.—If new contacts are necessary, first replace timer lever KC-335 and contact screw KC-312 with new parts.* Adjust the contact screw until the points separate .020″ to .025″, after which the screw is secured by tightening the lock-nut. Next note if the points are square with each other and touching over their entire surface. If not, loosen the nuts holding the contact support. This can then be moved sufficiently to line up the contacts properly. Tighten and lock all nuts.

The timing lever is lubricated by a small wick contained in the hollow spindle underneath the spring clip. Three drops of oil in this wick once a season is sufficient. The grease cup on the distributor shaft should have one-half turn each 500 miles of service.

*The marks KC-335 and KC-312 appear stamped on new parts.

Setting the Ignition.—If the timing of the ignition has been disturbed and it is necessary to reset it, this can be accomplished by loosening the cam screw, the cam lightly on its seat, and turn it in the direction in which it rotates, until then raising the cam off its taper on the shaft by prying it up with a screwdriver. (See Fig. 418.) To reset the cam: First set engine with

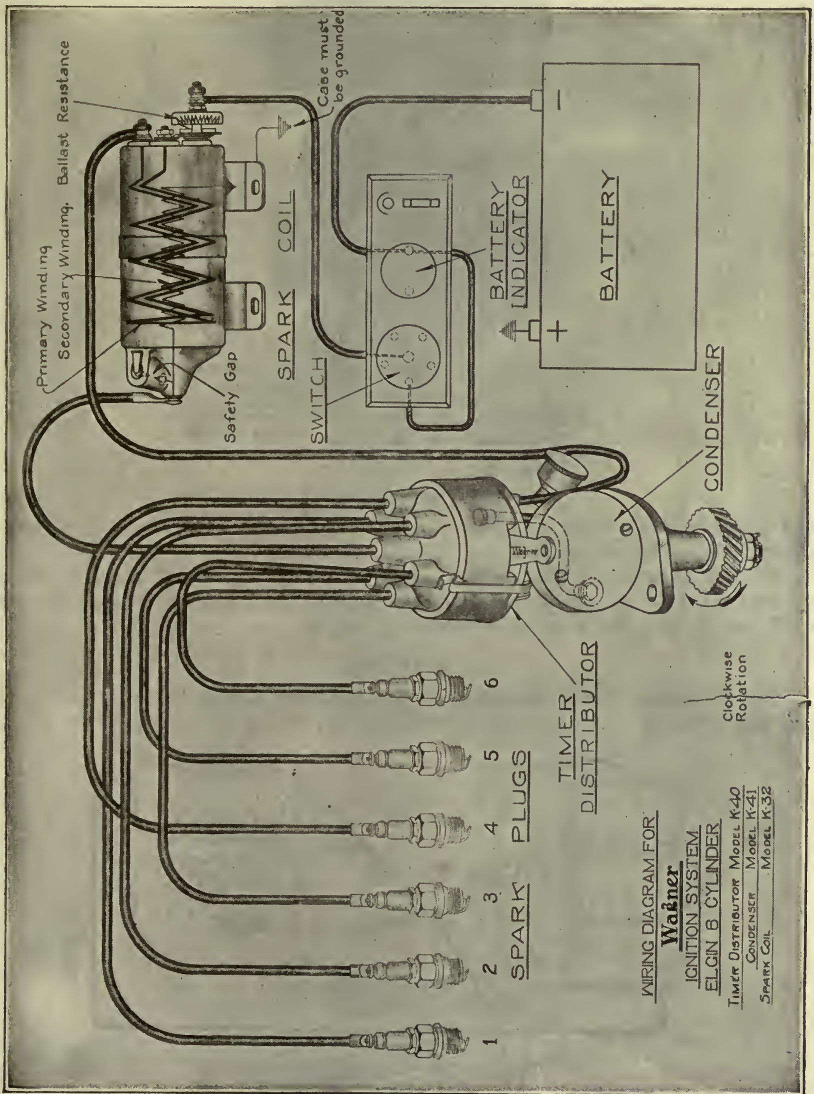


Fig. 419. Wagner Wiring Diagram.

cylinder No. 1 on T. D. C. compression stroke. Retard the spark fully. Rest the slot B is opposite the timing lever C, and the point of the cam in line with the slot is just starting to open the contacts. Tap the top of the cam lightly with the butt of the screwdriver. This will hold it until the adjusting or clamping

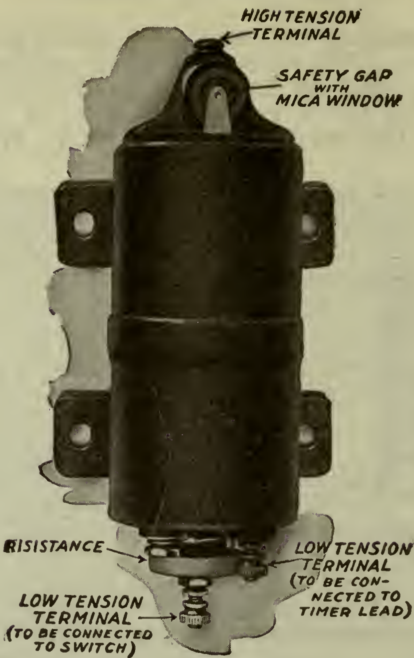


Fig. 420. Wagner Spark Coil.

screw can be replaced. Test after tightening the cam screw to see that the setting has not been changed.

Wiring Diagram.—The wiring diagram shown is for the Elgin 6, but may be considered as typical of the Wagner system. The student will be interested in tracing out the high and low tension circuits.

JOB 125.

Open Circuit in the Primary of the Ignition Coil.—To test for an open circuited primary, a 6-volt battery is connected to the terminals of the primary

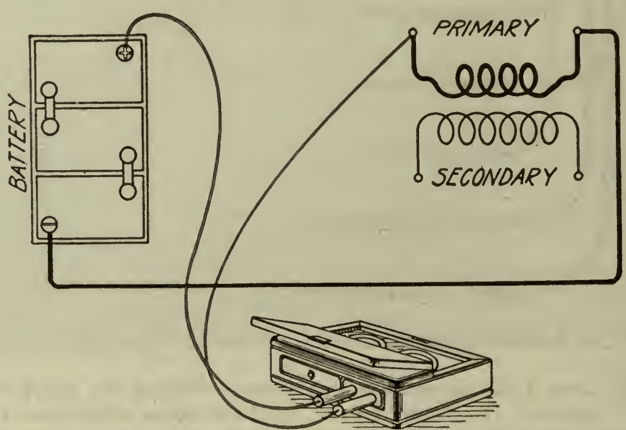


Fig. 421.

winding of the coil with the ammeter in series as shown in Fig. 421. In most coils the current flow will be about ten amperes if the winding is in good condition. (Consult the coil manufacturer to find out the actual value or try out several coils known to be good.)

Refer to Chapter 14, Job 160, for instruction on the use of the Fault Finder Test Set.

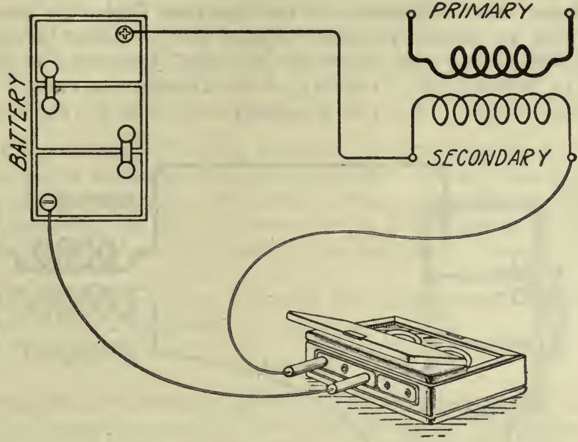


Fig. 422.

JOB 126.

Open Circuit in the Secondary of the Ignition Coil.—To test for an open circuited secondary, connect the thirty-volt range of the instrument in series with the battery and the secondary winding of the coil as shown in Fig. 422.

An open circuit will be indicated when the reading is zero.

For a good winding the reading will be about three volts.

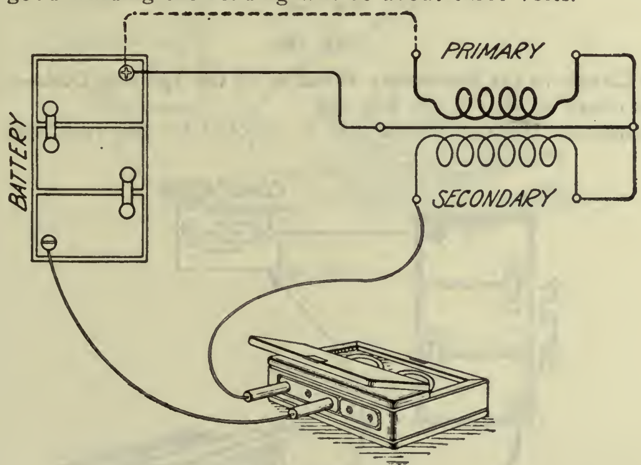


Fig. 423.

JOB 127.

Open Circuit in Ignition Coils with Connected Windings.—In some coils the primary and secondary windings are connected together with the coil as

shown in Fig. 423. When this is the case the test can be made on the secondary, as shown by the full line connection, and on the primary by changing the connection as indicated by the dotted line. The thirty-volt range is used. Zero reading in either case indicates an open circuit.

JOB 128.

Short Circuit in the Primary of the Ignition Coil.—To determine if the primary winding is short circuited, connect the ammeter in series with the winding and the battery as shown in Fig. 421, Job 125. A short circuited winding will be indicated by a reading on the ammeter in excess of the normal current for a good coil. (Consult a coil manufacturer for the normal value of a current.)

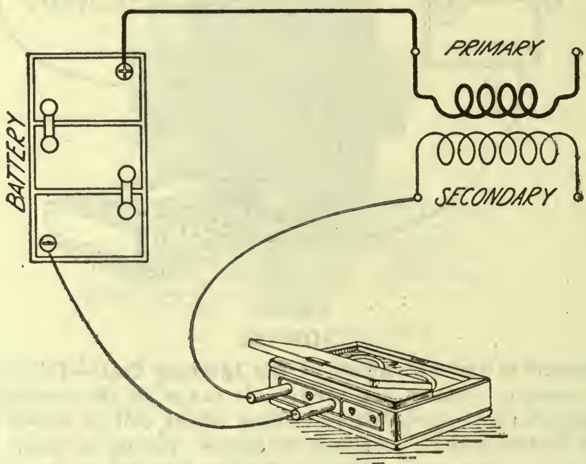


Fig. 424.

JOB 129.

Short Circuit in the Secondary Winding of the Ignition Coil.—Connect the thirty-volt range as in Job 126, Fig. 422.

A completely short circuited coil is denoted by the voltmeter indicating

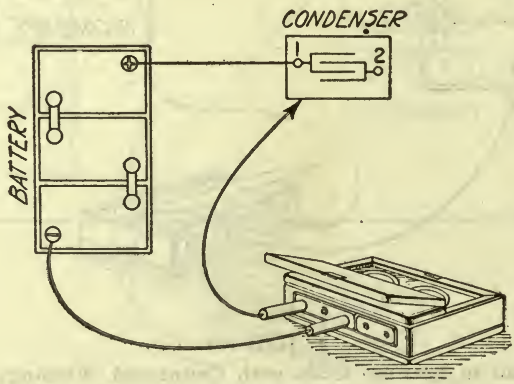


Fig. 425.

the battery voltage. Partial short circuit will result in a value less than the battery voltage but somewhat higher than three volts.

JOB 130.

Ground Between Primary and Secondary Windings.—Connect the battery and the thirty-volt range of the instrument, as shown in Fig. 424, to one end of the primary and one end of the secondary windings. If the coils are grounded on one another an indication will be obtained.

Note:—This test cannot be performed on coils having **internally** connected windings.

JOB 131.

Grounded Condenser.—Connect a six-volt battery and the thirty-volt range of the instrument in series as shown in Fig. 425. Connection is made to only one terminal of the condenser, the circuit being completed through the metal case of the condenser. If the condenser plates under test are grounded to the case, an indication will be obtained. No indication denotes absence of a ground.

Change the connection from terminal No. 1 to terminal No. 2 and repeat the test on the other set of plates.

JOB 132.

Short Circuited Condenser.—Connect a six-volt battery and the thirty-volt range of the instrument in series to the terminals of the condenser. Fig. 426.

No indication will be obtained if the condenser is good. If short circuited, an indication will be obtained.

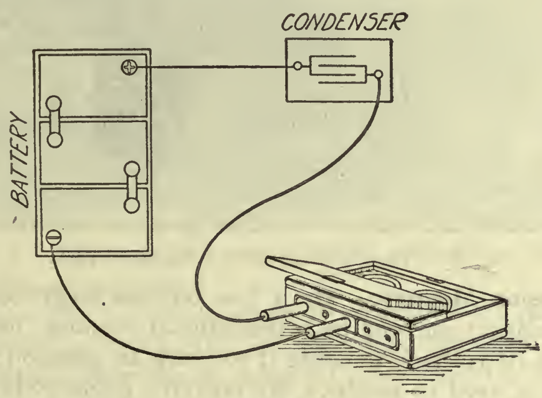


Fig. 426.

CHAPTER 13

MAGNETO IGNITION

This type of automotive ignition is divided into two general classes. These are low tension magneto and high tension magneto. Low tension, being the most closely connected to battery ignition, will be described first. Much of the matter given with relation to the low tension is applicable to the high tension magneto. Low tension magnetos, excepting the type used on the Ford car, are considered obsolete for automobile use.

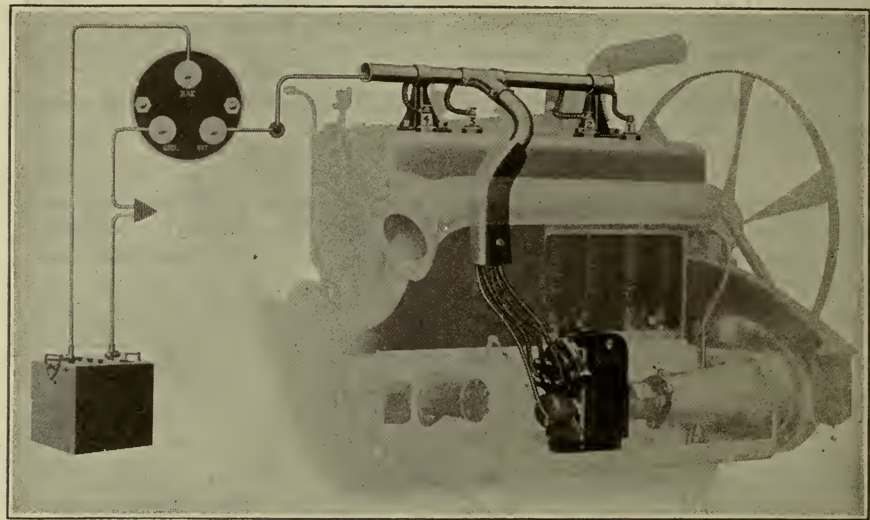


Fig. 427. Electrical system on Packard truck.

Low Tension Magneto.—By a low tension magneto is meant a machine generating current in a mechanical manner, but of insufficient pressure, or voltage, to cause it to jump air gaps on spark plugs. The machine is used to produce the current, while coils are used to step it up to a high tension point where it will jump the plug points.

The voltage of the low tension magneto is about six volts in most cases. The Ford magneto generates about eighteen volts. Magnetos generate A. C. current only. The action of coils is not materially influenced by this fact since the magneto is usually timed so that the one-current impulse as generated in one-half revolution is used to produce the spark in each cylinder. While the current does reverse in the armature and consequently within the coil, it does not alternate in producing any one spark. It is rather only in the direction in which the separate or successive sparks flow that there is reversal

of direction. In other words one spark will follow the high tension wire to the plug and return to the coil through the engine frame, the next due to the reversal of direction within the magneto will go through the ground to its plug and return to the coil through the wire.

To illustrate more fully. When A. C. current is used to light the bulbs in house lighting, the direction of flow of the current through the filament reverses a number of times per second. Although an A. C. machine is used to generate the current which is stepped up and used to ignite the fuel charge within the cylinder, it flows in only one way since only one wave is used to produce any one spark. Each succeeding wave, although in different or alternate directions, is used to produce one spark and ignite one and a separate charge. The current waves do not alternate back and forth in producing the spark in any one cylinder where the shuttle or H type armature is used.

H or Shuttle Type Low Tension Magneto.—Where this type of armature is used for low tension magneto work there is but one winding on the armature. In constructing the magneto the usual design is to mount the armature between two pole shoes on the outside of which are bolted or screwed the permanent magnets. The permanent magnets are used to produce the magnetic flux or field. Brass or bronze bearing supports are mounted across the ends of the pole shoes to carry the armature. Thus the armature is rotated on its bearings within the magnetic field, cutting the lines of force or magnetic flux, and taking off through its windings the primary current thereby induced.

Inductor or Stationary Coil Type.—In this type of magneto the coil or winding is made to remain stationary, while the magnetic flux is made to cut the winding either through a rotating inductor or a rotating field. These points are brought out more fully when the various types are considered.

Magnets.—The nature of magnets as well as the methods of constructing, charging, and caring for them was described in Chapter 10. In the practical application of magnets to the magneto certain forms are standard. In lighter magnetos either a wide single magnet is used, or two lighter ones side by side. In heavier machines where more is demanded of them the magnets may be made to fit one over the other, and as many as four, six, or nine are used in a group. Whatever the number used, the purpose served being the same in all cases, they maintain a permanent magnetic field from which may be induced a primary circuit to feed the coil and produce a jump spark.

Pole Shoes.—In the nature of the magnets the lines of force are stronger at or near the ends than elsewhere. To facilitate this flow of the lines of force and to insure a proper field of magnetic flux for the armature to turn in, much attention is given the design of the

pole shoes. Each manufacturer gives special attention to this and the slight differences will be evident in the illustrations and in the models the student comes into contact with.

Aside from the special magnetic duty which they perform, the pole shoes are used very often to build up the other units of the machine. To them are fastened the magnets, the bearing supports, dust covers, and base.

Non-Magnetic Metals.—Owing to the fact that the magneto must be very compact and carefully enclosed to exclude all dust, dirt, grease, etc., as well as the fact that it is usually mounted directly on the engine, care must be used in its mounting and construction to

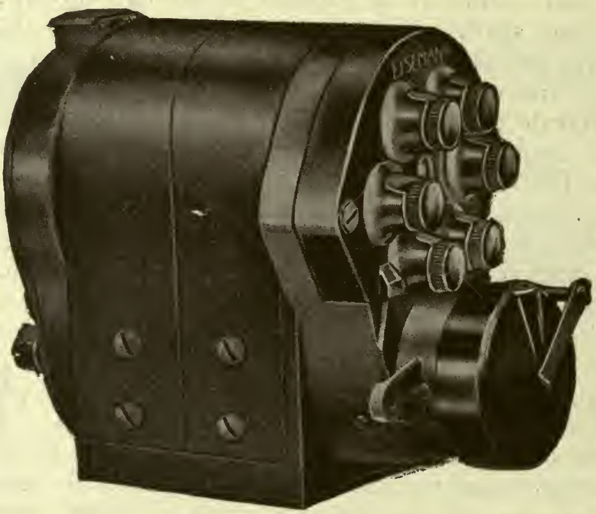


Fig. 428. Eisemann High Tension Magneto.

prevent any disturbance of the magnetic field. By this is meant that nothing must be allowed to come in contact with the magneto which will divert the flow of the flux from the north pole to the south pole of the field. For this reason the base, bearing supports, armature ends, and certain other parts are made from non-magnetic metals such as bronze, brass or aluminum. In some cases screws of brass are used, and where this is the case iron should never be substituted. By non-magnetic metals are meant those not attracted by the magnetic lines of force as are iron or steel. To avoid troubles hard to locate, use extreme care in rebuilding a magneto.

Armature.—The armature of the H or shuttle type shown in Fig. 484 and elsewhere is commonly used in both low and high tension magnetos. No shaft runs through it. As mentioned before, non-magnetic metals are used to hold the ends of the armature together and to support the stub shafts on which the armature turns.

Bearings are usually ball bearings. The magneto must be very carefully assembled since very slight clearance is allowed between the armature and the pole shoes. Sometimes the apprentice will allow the screws used for holding the parts together to become mixed, with the result that the ones which are a bit too long may project through the pole shoes and damage the armature.

Slip Rings.—The nature and purpose of the slip ring was previously explained. One or two may be used on the magneto. If only one is used the one end of the primary winding is led to it and fastened in direct contact. On this slip ring a carbon brush rides and carries the current to the external circuit. The other end of the primary winding is grounded through the shaft and bearings, or some special form of ground connection may be used. This furnishes the

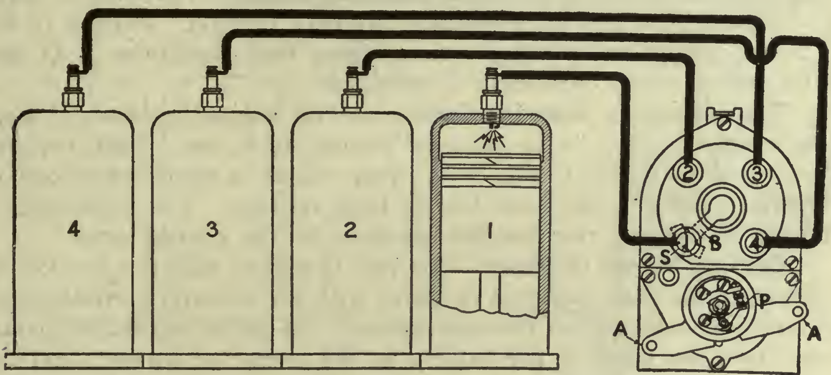


Fig. 429. Magneto Firing Order. 1-2-4-3.

other connection to the external circuit. Where two slip rings are used one is provided at each end of the armature. The current may be taken off direct, but the one on the rear of the armature is frequently grounded through a small carbon brush in the dust cover, or within the base. Sometimes the end within the magneto is grounded through a brush onto the bearing support. This takes the place of a slip ring. In the case of the low tension magneto the slip rings conduct only low tension current as there is no high tension current within the armature winding.

Breaker Points.—In magnetos of the shuttle armature type the machine must be driven in fixed relation to the engine speed. In a magneto for a four-cylinder engine the armature turns at crank shaft speed that is one to one. If the engine is a six-cylinder one, then the armature turns at one and one-half crank shaft speed or one and one-half to one. This the student will note provides for one-half of one revolution for each cylinder fired. This is absolutely essential as two sparks are available for each revolution of the armature. In

other words, the machine is so designed that at two points in each revolution of the armature the maximum number of lines of force is being cut by the armature windings. When this condition is present the current wave is said to be at its peak, and this is the time to open the contact points. When the current wave is at its peak the magnetism of the coil will be at its maximum, and as the points open there is the maximum break of magnetic lines of force, and consequently the maximum intensity of high tension spark at the plug points. This means that as the points open the armature would be close to the position shown in Fig. 449. A retard and advance range of about 35 degrees is available with this type armature. That is, the peak of the current wave is great enough or long enough to permit of advancing or retarding the opening of the points within the range mentioned, and still have sufficient voltage to produce a spark at the plug by aid of the step-up or transformer coil. Periods of no, cr zero, current are reached twice during each revolution. At this point the direction of current is reversed.

Transformer or Step-Up Coils.—Several distinct methods of stepping up the current in the external circuit are in use. Each requires the use of an ignition coil, or in other words, a transformer coil to transform the current from low to high tension. The difference in the two systems is the position occupied by the contact point.

Contact Points in Series.—By this is meant that the breaker or contact points are connected in series with the armature winding and the primary winding of the step-up coil. In other words, the armature takes the place of the battery as the source of current, and the action is exactly similar to the standard battery system. The current generated by the magneto flows into the primary coil of the transformer, thence back again to the armature. The contact points, being closed, permit this flow. When opened they check or stop this flow. This causes the lines of force about the coil to drop back to the core. The collapse and quick return of these lines of force is insured by the condenser action. The induced current within the secondary coil, due to the rapidly falling lines of force, is high and is used to jump the plug points. It will be seen that the induction is dependent on the rapidly collapsing lines of force. The second method is exactly the reverse in action. Rapidly built up or out-going lines of force are depended on in this case for high tension induction.

Shunt Current Interruption Induction.—The same coil and low tension magneto with condenser and interrupter is used. However, instead of taking the current from the magneto armature where it is generated through the primary winding of the coil and then back to the magneto, it is led through a shunt and directly back to the armature through the magneto points which are closed at this time. This insures a high pressure being built up within the magneto armature.

When the armature is in a vertical position, or position of greatest voltage, the interrupter points are opened. The condenser is across the points so that it is charged instantly, but the primary circuit of the coil is also across the points so that it affords a second path of travel for the current being generated. Since, however, the shunt affords an easier path, little will flow to the coil until the points separate.

When the points separate, the condenser is charged at the same time that current from the armature surges through the primary winding of the coil. The discharge of the condenser aids the current surging through the coil from the armature, and both together produce

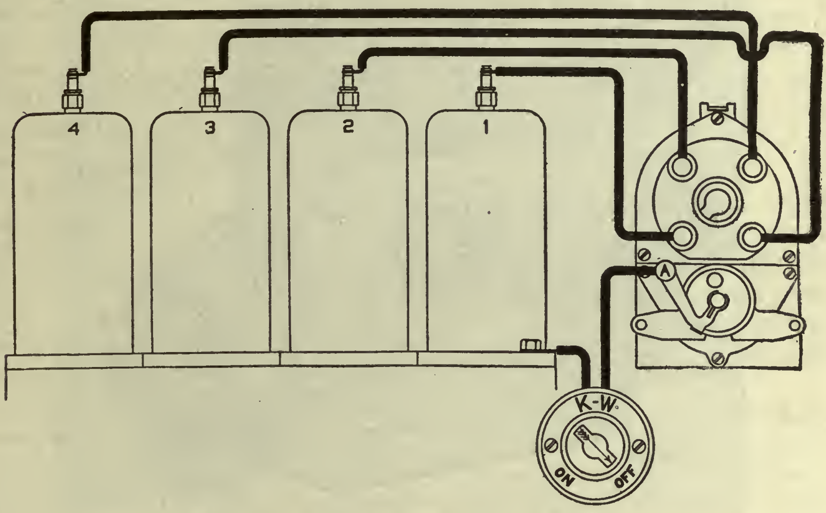


Fig. 430. Method of Wiring in a Switch.

such a rapid or instantaneous building up of magnetism that the rising or outgoing lines of force cut the secondary coil with such rapidity and in such numbers that a spark is available from the induced current, to ignite the charge within the cylinder. The student has seen that this is the exact reverse from the method used in the battery and in the other method of utilizing the low tension magneto, in that the induction of secondary current takes place on magnetizing the coil rather than on demagnetizing it. After the first spark is delivered and the points have closed again, the armature will start building up for the next spark which will occur as the points are opened after one-half revolution from the point of first break and spark. Each half revolution a spark is delivered to the engine. Two of these sparks are from the action of one of the breaker lobes, the other two from the other lobe. Sometimes a car having magneto

ignition seems to "hit" better on two cylinders than on the other two. This can often be traced to imperfect breaker lobes or cams.

Distributing High Tension Current from a Low Tension Magneto.—The current is generated within the magneto, is taken out of it to the transformer coil where it is stepped up through the induction method from about six volts to fifteen or twenty thousand, when it is returned to the magneto to be distributed to the proper cylinder on the engine. It enters the center of the magneto distributor on a high tension wire, and then is carried to the proper contact within the distributor cover by the distributor brush. The distributor on the

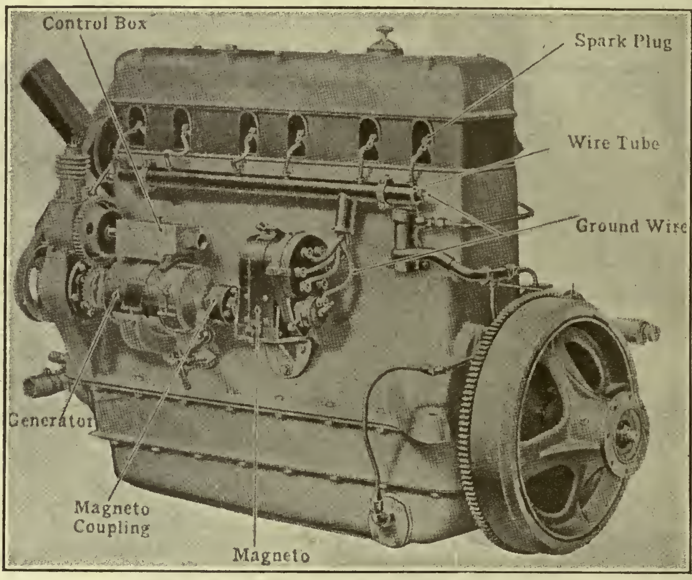


Fig. 431. Magneto Installation.

magneto is similar in action to the distributor head for battery ignition. Sparks are distributed to each segment in turn, but the wires running from the segments must be carried to the proper cylinders to give correct firing order.

Timing Spark on Low Tension Magnetos.—It has been shown that the magneto armature of the H type runs at a fixed speed relation with reference to the engine crank shaft. The one to one relation for the four-cylinder engine is used here for an illustration. Two sparks are generated each revolution, four sparks are produced in two revolutions. Four sparks are needed to fire the four cylinders of the engine in two revolutions. Driving the armature of the magneto at crank shaft speed cares for the proper number of sparks but provides no speed fitted to distribute them to the cylinders at correct time. Accordingly a gear is fitted onto the armature or armature

shaft which drives another gear carrying or turning the distributor brush. The gear ratio is two to one. The armature gear is smaller and turns twice while the distributor gear turns once. The desired result of distributing the four sparks to the four cylinders is thus secured.

For a six cylinder the distributor brush is slowed down to turn once to three turns of the armature, but the armature is driven at one and one-half crank shaft speed so that the distributor gear and brush still travel one turn to two of the crank shaft. However, six sparks are produced and delivered in two turns of the crank shaft, thus firing all cylinders. This is the working out of the ignition for the four-cycle engine no matter how many cylinders. This was explained in Chapter 7. If a magneto is removed from the engine it may be replaced on the engine out of time. Care should be used to observe proper markings and timing of valves with reference to compression strokes. Magnetos dismantled may have their internal timing disturbed unless due care is used. These matters are treated in detail elsewhere.

Dual Ignition.—By dual ignition is meant not double, but rather two kinds of ignition using the same set of plugs, spark plug wires, and distributor units. In connection with the low tension magneto, dry cells are used as the source of current supply for starting, after which the switch is thrown in such position as to permit of operating the engine on the current generated by the magneto. A storage battery may be used in lieu of dry cells.

Dual Ignition Switch.—The switch for the dual system is arranged to substitute the battery as the source of current supply for the magneto, and vice versa. One throw of the switch performs the operation of cutting out one source of supply and cutting in the other, thus making the operation of starting on battery current and running on the magneto practicable. If the change is not quickly made the engine will stop.

Push Button Starting.—Where dual ignition is used it is general practice to place a push button in the switch. This push button may be made to take the place of the interrupter or contact points. Vibrating the push button with the fingers causes a spark to be produced within the cylinder on compression. If a fuel charge properly compressed is present the engine will start when this spark occurs. The uncertainty of the engine stopping with a cylinder ready to be fired makes the system an uncertain proposition. Along with the other parts of the low tension magneto this, while still found, is considered obsolete.

Low Frequency Inductor Type Magnetos.—In the low frequency inductor type the magnets and pole shoes constituting the field are very similar to the armature type. However, instead of the armature

with its slip rings and revolving winding, an inductor of the nature of that shown in Fig. 441 is used to carry the flux through a stationary coil. The inductors are so designed that in certain positions they act as a bridge to carry or conduct the magnetic flux from the north pole to the south pole. However, the inductors are so made and mounted that a coil rests between them over the shaft. When the magnetic flux flows through the inductors, it is made to cut the windings of this coil. The more flux flowing through the inductors and coil the more current induced. As in the other type, there are zero points to the current. The current is alternating. The current waves reach a peak and it is at this peak or as near the peak as practicable that the points must be set to break. The current is a pulsating A. C. current for the following reason. On one position the flux flows from the north pole through the one inductor, through the coil, through the other inductor, and then into the south pole. With the next half revolution of the inductor the other inductor arm is at the north pole. Consequently in this case the flux flows into this one through the coil and out of the other one. The flux has cut the coil windings first in one direction then in the reverse direction. The current induced, as previously explained in Chapter 10, bears a definite relation to the direction in which the flux cuts the coil or the coil cuts the flux.

No Brushes.—Since the winding is stationary, there is no need of making any provision for slip rings or brushes in this type of magneto. The ends are either both led to terminals, or one grounded and the other provided with a suitable terminal. As the current is taken off it is A. C. current, but here again the machine is run in fixed relation to the engine. Only one current wave or pulsation and only the peak of that is used to produce a spark. As previously explained, each of these waves in turn is carried to the step-up transformer and used to induce the high tension jump spark current which is led along one wire to the plug for a certain cylinder. While the output of the machine is A. C. current, the single wave used for any one spark as well as the induced current is D. C. current. There is in reality no difference in the action of this type of magneto and that of the shuttle or H armature type, excepting only in the manner in which the flux cuts the coil windings to produce the low tension current. Each is provided with breaker points or interrupter for breaking the low tension current, and a distributor for distributing the high tension current to the plugs as it is brought from the transformer coil where it has been stepped up. One advantage of the inductor type is that the current will raise to a peak and hold that value for some little time before it drops back toward zero value.

The armature type, having reached maximum potential or value, starts dropping down immediately. The result is that the armature

type will not give quite as hot a spark on retard as it will on advance, while the inductor type will, approximately the same value of current being available for the entire range. Being a low frequency machine the inductor type must be driven as is the armature type at a fixed speed relation with the crank shaft. That is a one to one ratio for a four-cylinder engine.

High Frequency Inductor Type Magnetos.—These may be on the general principle of the above if more inductors are added. The Ford magneto is of the high frequency inductor type. With the armature type or low frequency type the current waves must be timed with the engine speed. This is necessary to insure the peak of a current wave available at the proper time. This does not apply

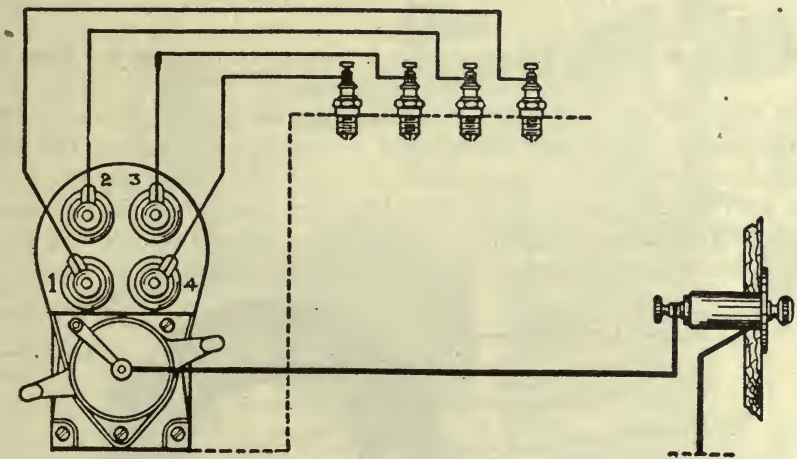


Fig. 432. Typical Magneto Wiring Diagram. (Wired without reference to firing order.)

to the Ford Magneto since there are sixteen pulsations or waves of current for each revolution of the magneto, which is built into the flywheel and necessarily rotates at engine speed. Taking this into consideration, the frequency of the waves is so high that current may be said to flow at all times.

Accordingly, in timing the engine it is not necessary to make allowance to have the spark occur at the peak of the current wave, as this point is arrived at so frequently that it would be difficult to find a point on the timer contact when the spark would be delayed more than a few degrees due to the lack of a high enough pressure or current. It is a matter of fact, however, that there may be a little variation of the timing of the spark due to the lack of a sufficiently high voltage from the generator or magneto. The spark may occur a few degrees early or a few degrees late.

Method of Generating.—Current is generated or induced to flow in the armature, or the inductor of the machine, by the field of perma-

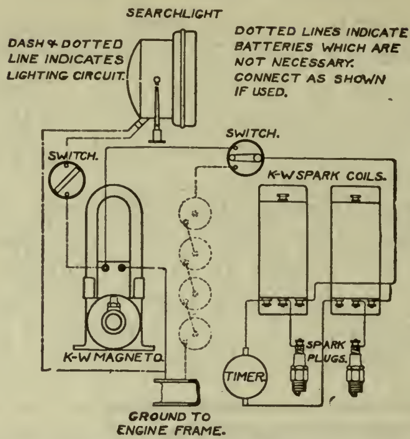


Fig. 433. K W Inductor Type Low Tension Magneto with Ignition and Light in Circuit. Battery Current for Starting.

nent magnets rotating in front of it and in close proximity to it. One thirty-second of an inch is allowed as clearance between the two. With sixteen magnets mounted with their like poles together, cutting past the sixteen inductor coils, it is seen that when the two north poles of a group are over the core of an inductor the flux will enter it and flow to the core of an adjacent inductor coil, from which it will

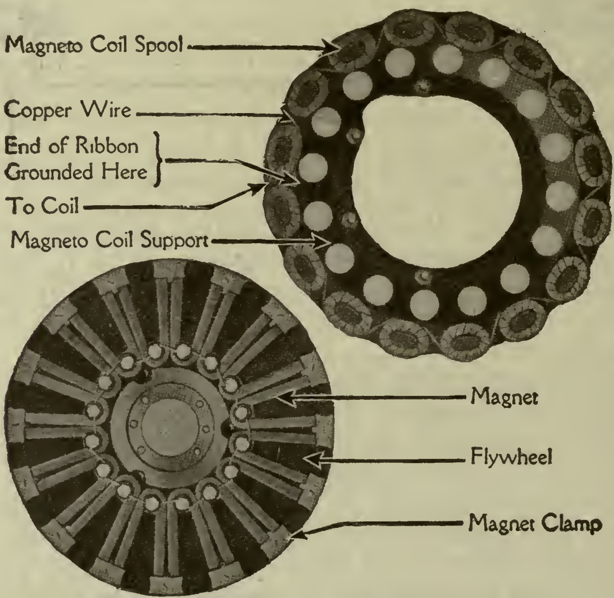


Fig. 434. Ford Magneto.

emerge to enter the south poles over it. This flow of the magnetic lines of force or flux induces a wave of current within the coils of the

inductors. Simultaneously with this action the same process is going on in seven other sets or groups of magnets and inductors. However, when the two north poles have advanced to the inductor over which the south pole stood, the magnetic flux flows into its core where it previously came out. This results, of course, in an alteration of the direction of flow and the second pulse of current is in the reverse direction through the inductor coils. When the next inductor is reached the direction of flow is again changed, and so on all the way around the inductors of which there are sixteen mounted on the one magneto coil assembly frame. Sixteen times in one revolution the

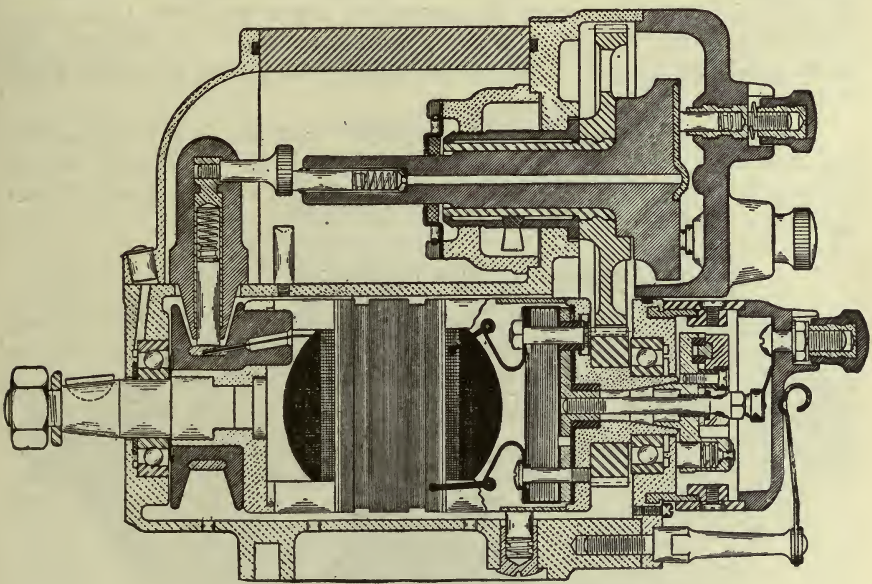


Fig. 435. Section High Tension Magneto.

direction of current is changed, because of a reversal of polarity in the inductors. Eight waves flow from the magneto into the external circuit in one direction, and eight others in the reverse direction. These waves follow each other so closely that there is a current flow even enough to be used for lighting as well as for the vibrating coils.

External Circuit on Ford Ignition.—One terminal of the low tension armature is grounded. The other is connected with the terminal mounted on the center of the top of the transmission cover case. Between this terminal and the ground or metallic parts of the car, all electrical units using the low tension current must be arranged. As described under battery ignition, the Ford ignition system brings the low tension current to the timer roller and from there to the timer segments as it rolls over them, then to the separate vibrating coils connected to the timer segments or contacts. The contacts within

the coil box are connected to the magneto terminal which completes the external circuit with reference to ignition. The coil box switch naturally must be considered as being placed in the circuit to open and close it, otherwise the engine might be cranked at any time with reference to the spark and would have to be choked to stop it.

The distribution of the high tension current was explained under the battery ignition. It is well to have in mind the fact that instead of one coil four are used, doing away with the necessity of distributing the high tension current through a special distributor. Any plug will receive a spark only when its respective coil is vibrating and the coil vibrates only when its respective segment in the timer is in contact with the rollers, and this roller can only be in contact with that segment when the cylinder to receive the spark is on the finish of the compression stroke.

The only other type of high frequency magneto is the one having the drum armature wound with a number of coils. This type may be used for lighting lamps, but not for charging a storage battery since only D. C. current may be used for this.

HIGH TENSION MAGNETOS

High tension magnetos are so called because the machine is complete within itself, and is able to deliver a high tension jump spark to the plugs without the aid of any outside help. No transformer coil of any nature, and no external units whatever are required.

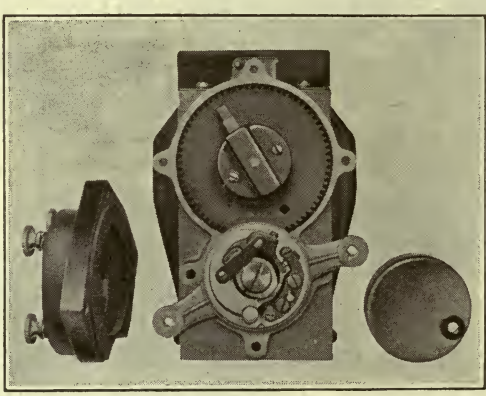


Fig. 436. Typical Magneto Construction.

All units for ignition either low tension or battery are still required, but all are built into the magneto itself. The manner of building in the high tension coil condenser distributor, etc., is of interest to the student.

High Tension Armature Type.—In this machine the arrangement of magnets, pole pieces, frame and general design are very

similar to the low tension of the same type. The main difference in principle of operation is the addition of the secondary or high tension coil over the primary or low tension coil on the armature. Other necessary units are also built in so as to make it self-contained.

Low Tension Circuit in Armature type.—In the high tension magneto the low tension or primary current is generated just as in the armature type low tension magneto. Not as many turns of wire are used due to lack of space on the armature. Two waves of current are generated again, one for each half revolution. These again are alternating. Just as the peak of the current wave is reached,

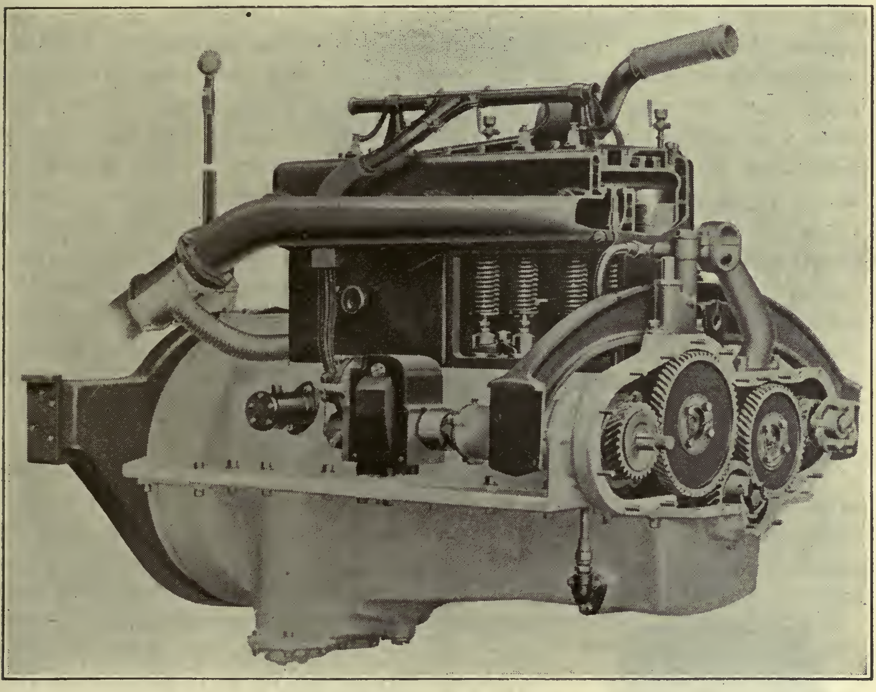


Fig. 437. Engine Timing Gears and Magneto Drive.

which is just as the armature shoe edge leaves the pole piece, the breaker points are opened. The action is the same as for the low tension or battery system. When the points open the lines of force collapse or fall back, cutting the primary winding which induces a higher voltage therein, which rushes into and charges the condenser. The condenser is mounted in the end of the armature. This condenser charge is immediately kicked back through the low tension circuit, thus assisting in completely demagnetizing the coil core and assisting in breaking down the lines of force. The final collapse is very rapid. This rapid collapse of the numerous lines of force causes

the induction of a very high tension current within the secondary winding. This is used to ignite the charge within the cylinder. It is taken off of the collector or slip ring, and is carried to the center of the distributor head by means of the pencil brush or distributing bar.

The student will note, however, that there is another feature which makes the high tension magneto superior to the low tension. While a current wave is being induced in the primary winding, one is being induced in the secondary winding even stronger than the first mentioned. This is induced by the secondary coil cutting the lines of force, just as the primary current is induced. The voltage or pressure generated by this method is not sufficient to jump the spark plug points, but it is there within the secondary winding attempting to flow along the wire to the collector ring brush and pencil, and by way of the distributor to the spark plugs. The pressure within the secondary coil is thus fairly high when the contact points on the primary circuit open. The opening of the points induces additional current and this is high enough to cause the current to break down the air gap momentarily. Once the gap is broken down and the current flowing, the voltage, which is generated within the secondary coil by the magnetic lines of force passing through the field from the north pole to the south pole, is sufficient to keep the current flowing in the form of a heavy burning spark. It is readily seen how this current flowing for a longer length of time (about 30 to 40 degrees of armature travel) will produce better ignition of the fuel charge within the cylinder.

High Tension Inductor Type.—In this type the general construction follows the low tension machine of the same type. An additional coil of fine wire is placed on the coil over the coarser primary winding. In this finer winding the high tension current is induced. The coils are again stationary over the inductor shaft and mounted between the inductor arms. These inductors or arms form the path for the magnetic flux to follow as it flows from the north pole to the south pole through the coil. Except for the fact that the coils are stationary, and the absence of brushes and slip rings, the action is the same as for the armature type.

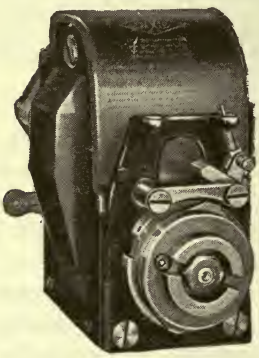


Fig. 438. High Tension Magneto (Dixie Aero).

When the breaker points open, a current is induced within the coarse or primary winding. This charges the condenser. The condenser discharges back through the primary coil. The rapidly collapsing lines of force induce a high tension current within

the coil of fine wire which is sufficient to jump the spark plug gap. Following on this comes the current induced by the flux, flowing through the high tension winding from the one inductor to the other. Just as in the armature type this current, while not sufficient to jump the spark plug gap of its own force, will continue to flow across the points once the gap has been jumped and the resistance overcome. The condenser is mounted within the base or at some other point convenient to the general type of construction.

JOB 133. K-W LOW TENSION MAGNETO GENERATOR.

All K-W magnetos are of the inductor type. The winding is stationary, the magnetic flux being conducted through the winding as it passes from north

Fig. 439. K-W Low Tension, Model DL

pole to south pole. The rotor carrying the inductors is the only moving part. The full action of the inductors is explained in Job 134 on the high tension type. The low tension magneto is of the high frequency A. C. type. This instrument is used to provide current for vibrating coils or for the lighting system. Friction or belt drive is used. It is not necessary to have the

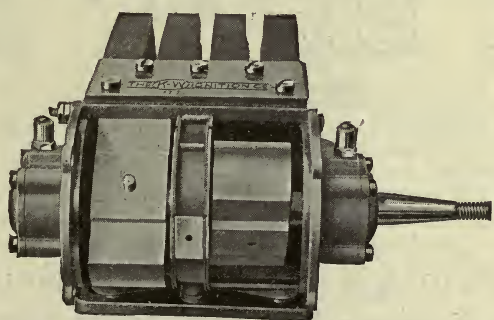


Fig. 440. K-W Low Tension Magneto. Note Inductors.

magneto timed to the engine. The speed of the low tension machine is from 2000 to 3000 R. P. M. Since the direction of flow of the magnetic flux changes four times per revolution instead of twice as in the H or armature type, the current pulsations per revolution are twice as many or four instead of two. This will give four times the rotor speed, changes, alternations or pulsations of current per minute, in actual figures from 8,000 to 12,000 pulses per minute. Since one-half of these are in one direction and the other in the other direction, the current is not satisfactory for charging storage batteries.

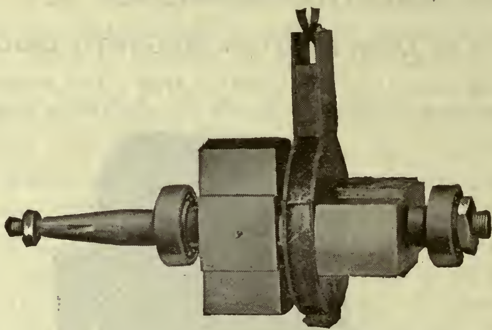


Fig. 441. Inductors and Stationary Coil Winding.

The rotor which is illustrated revolves in two sets of the latest improved ball bearings. It does not rub against or touch any other parts of the generator as all other parts stand still. No brushes or slip rings are needed.

Winding.—The winding shown in position on the rotor consists of a strip of copper wound spirally around the core of the revolving rotor. Terminals

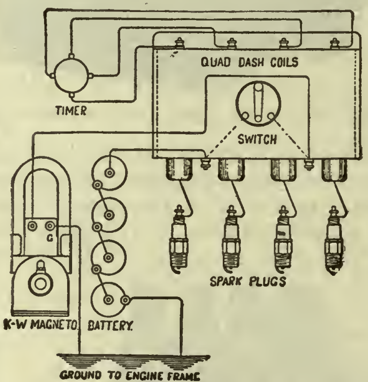


Fig. 442. Low Tension Magneto with vibrating coil.

of the winding extend through the top of the pole pieces in which the rotor revolves. They are securely attached to the binding posts found at the end of the generator. The wiring diagram shows how the magneto is wired in connection with a quad dash coil for ignition on a four-cylinder engine.

JOB 134.—K-W HIGH TENSION MAGNETO.

Principle of Operation.—The K-W high tension magneto is used very largely on heavy duty motors, as trucks and tractors. The same principle is

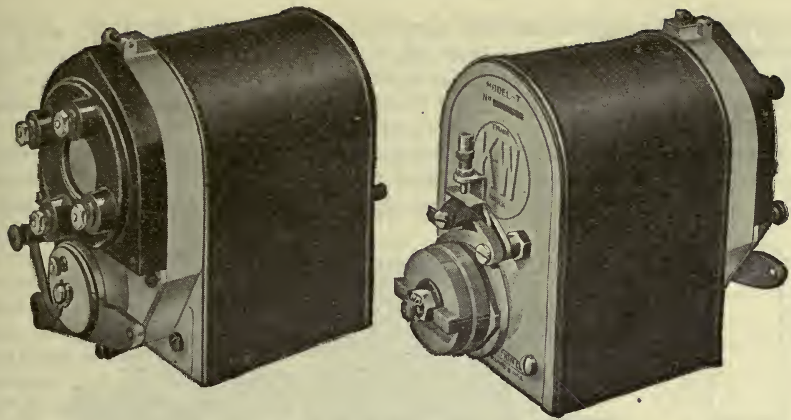


Fig. 443. K-W High Tension Magneto.

used as in the high frequency low tension machine. The rotor is the same general style. However, the high tension machine is fitted with the usual circuit breaker and distributing mechanism. It must be driven as are all high tension machines in fixed relation with the engine. Flexible drives such as friction or belts cannot be used.

Winding.—The primary winding is on a soft iron core. Refer to Fig. 444.

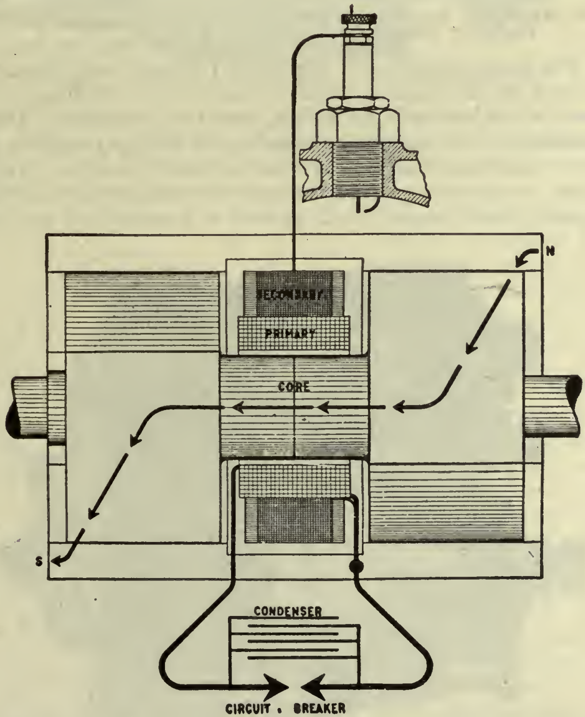


Fig. 444. K-W Magneto. Arrows indicate path of Flux.

The primary winding forms the core for the secondary winding, which is much shorter than in the armature type. The core of the winding is located in the direct path of the greatest number of lines of force flowing from the north pole to the south pole. These lines of force are indicated by the arrows in Figs. 444 and 445. The winding is stationary.

Inductors, Rotors and Pole Shoes.—The inductors are part of the rotor. They are made from soft iron machined to a close fit and placed on the rotor shaft at right angles or ninety degrees apart. The pole pieces or shoes differ from the usual armature type and are mounted on the machine at a ninety degree angle with respect to each other. This harmonizes with the rotor construction and accounts for the four current waves per revolution of the rotor. Fig. 445 shows the pole shoes in section. The path offering least resistance to the magnetic flux is indicated in the same figure. It enters one extension of the rotor and from it passes into and through the core and coil windings, after which it follows along another arm or extension of the rotor to the south pole. The next extension of the rotor to come into close range of the north pole is one on the opposite side of the coil or winding. Consequently the next wave of current will be in the opposite direction. The change of direction producing A. C. current is desirable, as before a current wave can be built up in a reverse direction the core and winding must have reached a zero point. In other words, the reversal hastens the collapse of the lines of force about the winding which is very much desired in producing a hot intense spark.

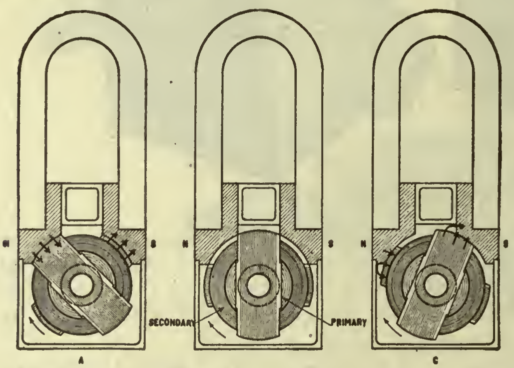


Fig. 445. K-W Magneto. Arrows indicate path of Magnetic Flux.

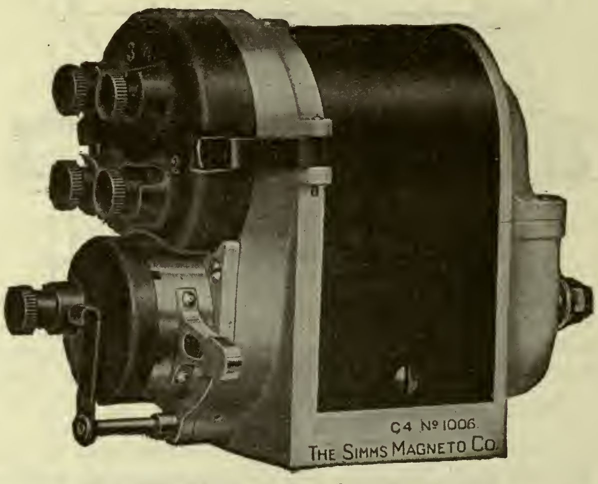


Fig. 446. Simms "C4" 4-Cylinder Magneto.

Fig. 445 shows three vital positions of the rotor. At A, the first position, the lines of force come down through the wing of the rotor, pass through the core, and then up through the opposite wing or extension. In B the rotor has been rotated to the next position, while in C the position indicated is the one occupied as the spark is produced at the plug. The high tension spark is delivered the instant the contact points open so that the position C indicates the point at which the maximum current would be generated in the primary.

JOB 135. SIMMS HIGH TENSION MAGNETOS.

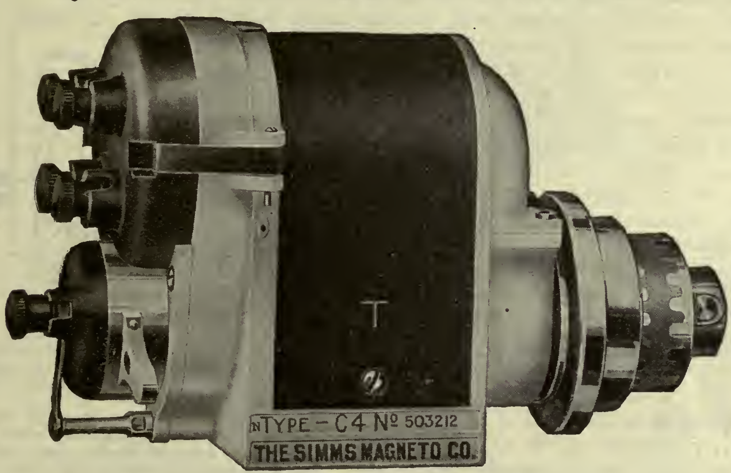


Fig. 447. Simms "C4" Magneto, with Impulse Starter.

Simms magnetos are of the true high tension type. High tension current is developed directly within the armature without the introduction of any exterior devices. This in itself is a considerable advantage over the low tension magneto, where a transformer coil is used to step up the low tension current, as there is a certain amount of current and time lost in this operation. The result is a weaker spark in the case of the low tension. A great deal of rather complicated wiring is required for the low tension magneto while the high tension requires only one cable to each plug and one ground wire connected through a switch.

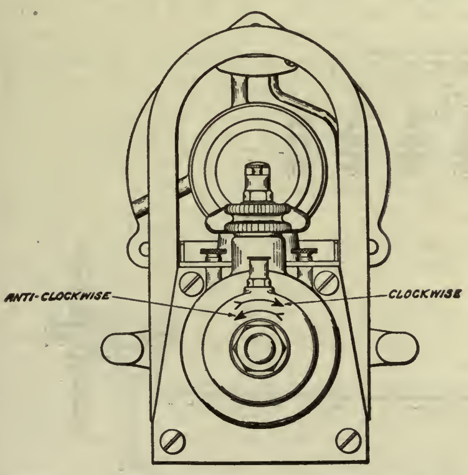


Fig. 448. Full back view showing driving end. Arrow indicates direction of rotation.

Pole Shoes.—A distinct feature of the Simms magnetos is their slow speed characteristic. They will give a heavy spark even when rotated at speeds of less than 40 R. P. M. This feature allows starting the engine on the magneto even where the cranking speed is necessarily slow. An inspection of the cross section of the pole shoes and

armature will show the student why the construction used will make for easy starting even on a retarded spark. Since the amount of current produced is dependent on the number of lines of force cut, this pole shoe is so designed as to cause a large number of lines to flow just as the armature breaks from the retarded position.

Contact Breaker.—The contact breaker is so designed that at high speeds the action is assisted, and not retarded by the centrifugal forces developed. Thus, there is never any danger of the ignition cutting out at high speeds.

Armature.—The high tension armature consists of a few turns of heavy primary wire over which are wound many turns of fine secondary wire. Enamel insulated wire is used and each layer is further insulated from others with sheets of oiled silk. After being completely wound, the armature is first placed in a tank under pressure. The tank is filled with insulating liquid. Next the armature goes into a tank under vacuum. As this operation is continued, first compression, then vacuum, all air is worked from the armature and all pores or small openings are filled with the insulating liquid, or dielectric. The armature is next baked in ovens to drive off all traces of moisture.

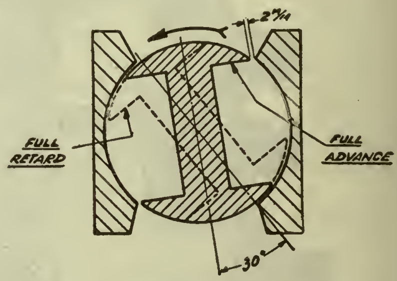


Fig. 449. Showing relative position of armature at both full retard and full advance with American Simms Patented Extended Pole Shoe.

As breaker points open at the fully retarded position the air space is but 1 m/m. At this point the maximum current is produced in the primary, thus explaining the American Simms easy starting feature.

Winding.—One end of the primary wire is grounded on the armature core, and the other end is brought out to the breaker points. The condenser is connected in parallel to prevent the points burning. The grounded end of the secondary is connected to the primary, forming a continuation of the same. The other end of the secondary is led to the slip ring, then through the conducting bar to the distributor, spark plugs, and ground on the engine, to the magneto base and back into the grounded end of the secondary.

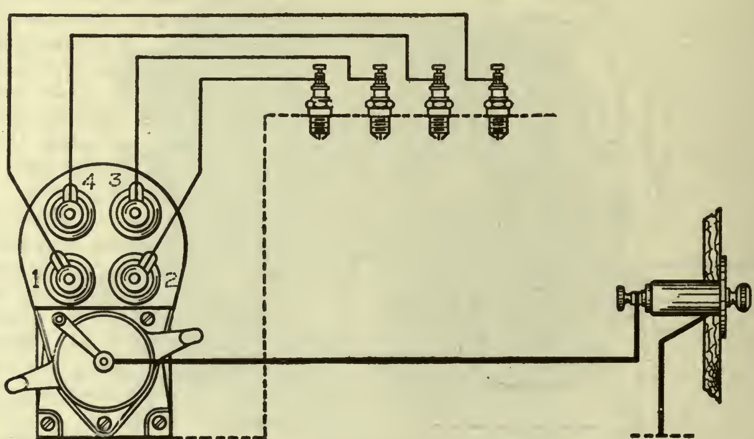


Fig. 450. Wiring Diagram for Simms High Tension Magneto. Four-Cylinder.

When the contact points are closed the primary circuit is also closed. Rotating this coil through the magnetic flux induces a low tension circuit in the primary coil. The primary circuit is then broken, inducing a high tension current of extreme intensity in the secondary winding, which is distributed to the spark plugs as mentioned above.

Driving.—The magneto must be positively driven by gears or chain. If the latter method is used provision must be made to take up the slack due to wear. For a four-cylinder four-cycle motor the magneto is driven at engine

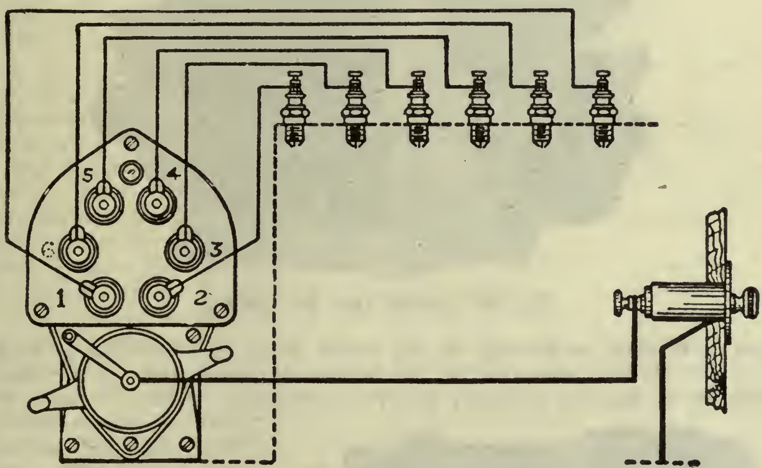


Fig. 451. Wiring diagram for Sims Six-Cylinder Magneto.

speed. For a six-cylinder motor the magneto is driven at one and one-half times engine speed. The magneto will operate only in the direction shown by arrows on the driving end plate.

Timing.—To time the magneto to the engine turn or crank over until cylinder No. 1 is on the compression stroke. This is the top dead center with valves closed. It is the beginning of the working stroke, and the connecting rod should be swung on the downward stroke side. Remove the contact breaker cover with the distributor cover or board. Turn the magneto armature in the direction which it must run until the contact points are just opening. The timing lever must be in full retard position. To secure retard, the lever must be pushed down with the direction of turn of the armature. The distributor brush must at the same time be in a position to touch the distributor segment serving cylinder No. 1. The driving gear or coupling should then be securely tightened onto the magneto armature driving shaft using the key in the key-way provided for same. If it is a case of retiming the magneto this work is likely already done.

With the engine in the position given and the magneto set as stated, the two are in proper position to be connected. Care must be exercised to see that they remain in their relative positions until finally secured together in this proper relation. It must always be remembered that the distributor brush rotates in the opposite direction to the armature. Terminal No. 2 on the distributor does not necessarily lead to cylinder No. 2, but must lead to that cylinder firing second. The same applies to cylinders and termnials 3 and 4 as well. The magneto has a timing range of 30 degrees, crank shaft travel. Any advance or retard desired more than that available from the action of the

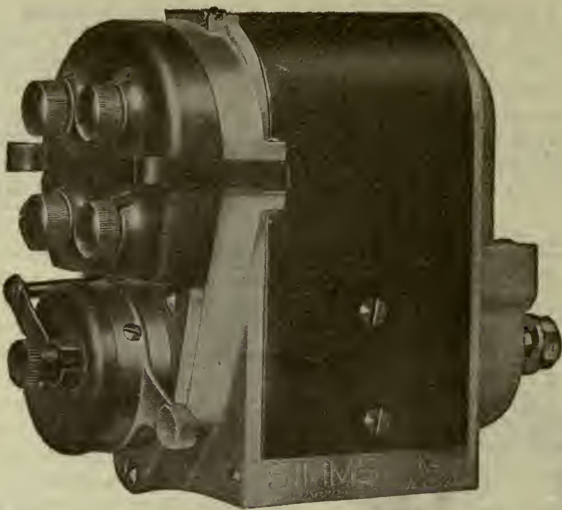


Fig. 452. Simms Type K4 Magneto.

timing lever must be secured on the engine alone by advancing or retarding the engine timing gears, but in no case must the setting of the magneto distributor or internal armature gears be disturbed, as these have a certain fixed relation to each other. Any different setting of these two gears will seriously impair the efficiency of the magneto. If necessary to disassemble these gears, make certain the proper marks are on them to insure proper reassembly.

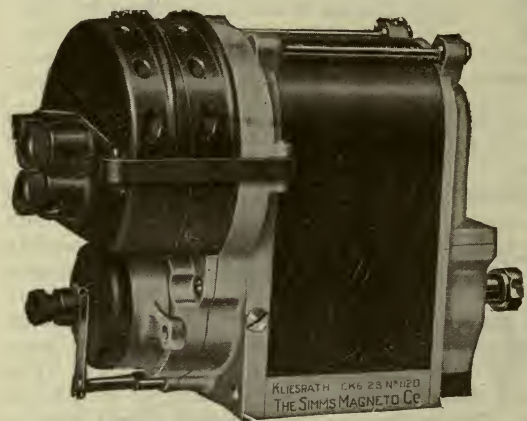


Fig. 453. Simms Magneto, Type "CK6", Two Spark.

Oiling Magneto. — The magneto should be oiled every two weeks or 1000 miles run, with four or five drops of light machine, not cylinder, oil in each of the oil holes, which are located over the armature driving shaft near the top of the distributor board. The contact points should never be oiled as it may cause serious trouble and undue wear of them.

Care of Contact Breaker.—The platinum points should be set to open on each cam about 1/64″. They should be kept free of oil and clean. They should make even contact over their entire surface. The contact breaker lever should pivot freely in the bushing, and should be inspected occasionally and freed of any oil or dirt accumulations. The points should be filed only if absolutely necessary and then with a fine flat file.

Distributor Board.—Cable connections should be kept tight and the inside of the board wiped occasionally with a dry cloth to remove any oil or dirt.

The distributor carbon brush should at all times press firmly against the distributor board.

Safety Spark Gap.—The safety spark gap is to protect the insulation of the armature from injury such as might be the case if excessive voltage were built up. This condition would be present should a high tension wire become loose or broken. The high tension spark will then jump the gap. If sparking should be detected in the safety gap which is located just over the driving spindle, the high tension wiring should be gone over thoroughly at both the magneto and spark plug ends. The distributor carbon brushes should be examined to see if they are in condition and making contact with the brass segment on the distributor rotor. If sparks can be obtained at the safety gap, it is an indication that the magneto is generating and that the trouble is likely in the wiring or spark plugs.

Removing Coupling.—If it is necessary to remove the coupling, great care should be taken that not too much force is used in the operation. The hard rubber slip ring just inside the housing is easily broken. On no account should any violent blows be struck on the end of the armature shaft. The garage press, or better still, the properly adjusted gear puller should be used if there is a tendency for the coupling to stick.

Spark Plugs.—The plug points should be set from 1/64" to $\frac{1}{32}$" apart. The first mentioned, or just a bit over, is recommended. If the distance is too great, it is possible that the motor will be hard to start. It must be borne in mind that while a spark will jump the points when the plug is lying on the cylinder, it does not follow that a spark will occur when the plug is in the cylinder. The reason for this is that the resistance of the gases under compression is greater than that offered by the atmosphere. If the insulation of the plug is cracked or broken, if the plug points are oily, or if the insulation is covered with carbon, the desired results will not be obtained. A cracked porcelain is often hard to detect. The easiest way is to insert a new spark plug or one known to be right. If this overcomes the trouble, it is then known to be with the plug.

Refusal to Start.—Should difficulty be experienced in starting after tests have proven the plugs are in proper condition, the wire connected to the contact breaker box should be removed. If this seems to correct the trouble the switch should be examined and any corrections necessary should be made. The wire removed is for the purpose of short circuiting the primary current when desiring to cut out the ignition and stop the motor.

JOB 136. BOSCH MAGNETOS, DU TYPES.

The types DU1, DU2, DU3, DU4, and DU6 magnetos are of the high tension series and are used respectively on one, two, three, four, and six-cylinder engines of the automobile type in motor car, marine, tractor, and stationary service. The type DU magnetos are usually used as sole ignition on an engine, or in some cases in connection with a battery system operating on a separate set of spark plugs. The DU magnetos are also used to provide battery and magneto ignition with one set of plugs. This is without alteration and is accomplished as indicated in Job 142 describing the Bosch Vibrating Duplex Ignition System.

Generation of Current.—The high tension current is generated within the armature, without the aid of any step-up coil. The timer and distributor are integral. The armature winding is composed of two sizes, one heavy and the other comparatively fine. The heavy wire is used as the primary or low tension circuit, while the very fine wire is the secondary circuit. The rotation of the armature between the poles of strong permanent magnets sets up or

induces a current within the armature primary circuit. This is further augmented at regular intervals in the rotation of the armature shaft by the abrupt interruption of the primary circuit by means of breaking the magneto interrupter points. At the opening of the primary circuit the resultant discharge of current from that circuit induces a current of high voltage within the secondary winding of the armature. The high tension current thus induced is collected by the collector ring on the armature and passed through the collector brush, then to the various magneto distributor terminals, each of which is connected by cable to the spark plug of its respective cylinder. The operation will be more completely understood by referring to Fig. 454 which shows the complete primary and secondary circuits.

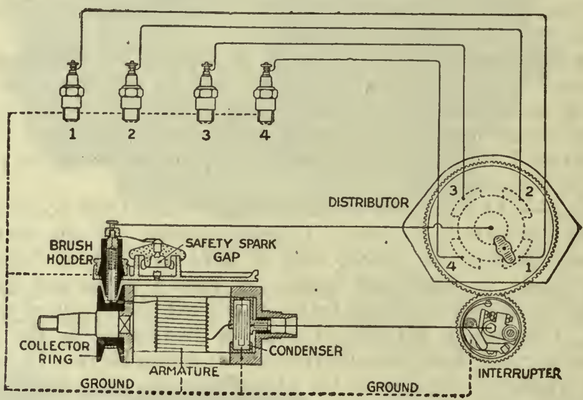


Fig. 454. Circuit Diagram Type DU4 Bosch Magneto.

Primary or Low Tension Circuit.—The beginning of the armature primary winding is in metallic contact with the armature core. The other end of the primary winding is connected, by means of the interrupter fastener screw, to the insulated contact block supporting the long platinum contact on the magneto interrupter. The interrupter lever, carrying a short platinum contact, is mounted on the interrupter disk which, in turn, is electrically connected to the armature core. The primary circuit is completed or made whenever the two contacts are brought together, and interrupted when the cams on the breaker mechanism cause these points to separate. The separation of the points is controlled by the action of the interrupter lever as it bears against the steel cams secured to the inner surface of the interrupter housing. The high tension current is generated in the secondary winding only when there is an interruption of the primary circuit. The spark occurs the instant the platinum points are opened.

Secondary or High Tension Circuit.—The armature secondary circuit is a continuation of the armature primary circuit, the beginning of the secondary being connected to the primary, while the end of the secondary is connected to the insulated collector ring. This is mounted on the armature shaft just inside the driving shaft end plate of the magneto. The collector brush, which is held in contact with the collector ring by the brush holder at the shaft end of the magneto, receives the high tension current collected by the collector ring, and by means of the conducting bar under the arch of the magneto, passes the current to the metal contact in the center of the distributor plate. From the latter point the high tension current passes to the distributor brush which is held in a brush holder mounted on the distributor gear, and consequently rotates with the gear.

Distributor.—Metal segments are molded into the distributor plate, and as the distributor brush rotates it makes contact successively with these segments. The segments in turn are connected with the terminal studs on the face of the distributor plate. The latter are connected by cable to the spark plugs in the various cylinders. In the cylinder the current, in the form of a jump spark, ignites the fuel charge and then returns to the magneto armature through the engine castings. This completes the circuit.

Safety Spark Gap.—In order to provide protection for the armature and other current-carrying parts the magneto is equipped with a spark gap called the safety gap. Under ordinary circumstances the current will follow its normal path to the spark plugs, but if for any reason the electrical resistance in the secondary circuit is increased to a high point as when a cable becomes disconnected, or a spark plug gap too wide, the high tension circuit will discharge across the safety gap. Otherwise it is inoperative.

The current should never be allowed to pass across the safety spark gap for any length of time. If the engine is to be operated on an auxiliary ignition system, the magneto must be grounded in order to prevent the production of high tension current. The switching off of the magneto switch will accomplish this by grounding the primary circuit. The snapping sound by which the passage of current across the safety gap may be noticed should always lead to an immediate search for the difficulty.

The safety spark gap is arranged on the dust cover over the armature, and consists of two short pointed electrodes supported a short distance from each other. One electrode is set on the dust cover itself and enclosed by a metal and wire gauze housing. The other electrode which is the insulated one is set in a steatite cover of the safety spark gap housing and is connected in the secondary circuit of the magneto.

Timing Range.—The magneto interrupter housing is arranged so that it may be rotated through an angle of 35 degrees with respect to the armature shaft. The movement of this housing in one direction or the other causes the interrupter lever to strike the steel cams earlier or later in the revolution of the armature. This causes the spark to occur earlier or later with relation to the stroke of the piston.

The spark can be advanced by moving the interrupter housing by means of the timing control arm in the direction opposite the rotation of the armature. To retard it, move in the direction of rotation of the magneto armature. The armature rotation is indicated by the arrow on the oil well cover at the driving shaft end of the magneto.

Cutting out the Ignition.—Since high tension current is generated only on the interruption of the primary circuit, it is evident that to cut out the ignition it is necessary merely to divert the primary current to a path which is not affected by the action of the magneto interrupter. This is accomplished as follows:

An insulated grounding terminal is provided on the magneto interrupter housing, with its inner end, consisting of a spring with carbon contact, pressing against the head of the interrupter fastening screw. The outer end of the grounding terminal is connected to a switch. Low tension cable is used for this. The other side of the switch is grounded by connecting it to the engine or other metallic part of the chassis.

When the switch is open the primary current follows its normal path across the platinum interrupter contacts, being interrupted at each break of these points. However, when the switch is closed the current passes from the head of the interrupter fastening screw through the grounding terminal cable and switch to the engine and thus back to the armature. Since the primary current

is not interrupted in this flow no high tension current is generated or induced within the secondary winding.

Oiling.—Aside from keeping the magneto clean externally about the only care needed is oiling of the bearings. There are two ball bearings supporting the armature and a plain bearing supporting the shaft of the distributor gear.

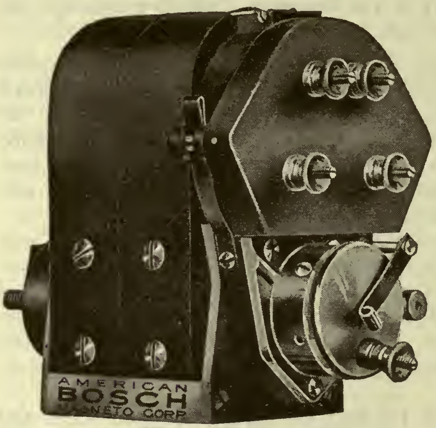


Fig. 455. Bosch Magneto.

Any good light machine oil may be used for this, but cylinder oil should not be used. Each of the bearings should receive two or three drops each 500 miles run. This should be applied through the oil ducts under the covers marked "oil" located at each end of the magneto.

The interrupter is intended to operate without lubrication. Oil on the platinum breaker points will prevent good contact causing sparking and burning as well as misfiring. Care should be exercised to prevent oil entering to these parts.

Starting the Engine. — When cranking a motor equipped with the D. U. magneto as sole ignition, the spark lever should be advanced a slight distance. In some cases of properly timed magnetos the advance may be one-third the full advance for hand cranking, and as much as one-half for starting motor work. This will permit easier starting. The most effective point for starting is quickly learned from actual experience. In hand cranking full advance is very likely to result in injury to the operator, and in starting motor work may result in injury to the apparatus.

Ignition Troubles.—Ignition troubles with the Bosch magneto may be divided into two classes. The first of these is spark plug trouble, the second, comparatively infrequent, magneto trouble. In the case of defective ignition the first point to determine is whether the trouble is with the plugs and external circuits, or within the magneto itself. In general, when only one cylinder misfires, the trouble is with the plug.

Plug Gap too Wide.—The distance between the electrodes of the spark plugs varies according to the individuality of the engines, but normally this distance should not be less than one-fiftieth inch. On the other hand, however, too wide a gap increases the resistance and interferes with the proper generation of current at low speeds. Difficulty in starting an engine and missing at low speeds are very often due to the spark plug gaps being too wide. As the actual use of the plugs shows a tendency for the spark to burn the plug gap wider, it is well to inspect the plugs from time to time to make sure that the gap is not too great. Readjusting the electrodes will remove any gap troubles. Unless quite experienced, the mechanic should test his work to see that all plugs are adjusted equally. If not, the motor will operate unevenly.

Plug Short-circuited.—This is usually caused by a cracked or porous insulator. Any of these conditions will cause misfiring by permitting the current to stray from its intended path.

Cables.—Misfiring of one cylinder, either continuous or intermittent, may be due also to a chafed or broken cable, or loose cable connection. The cables should receive careful examination, special attention being paid to the insulation. The metal parts of the cables must not come in contact with any metal

parts of the engine or magneto, except those designated as being correct in the instructions preceding this.

Ignition Fails Suddenly.—A sudden failure of the ignition may indicate a short in the low tension cable. This condition may be caused by the presence of moisture or dirt, defects in the cable or cable insulation, or to faulty connections at the switch or even a short-circuited switch due to the failure of the switch mechanism. A test for trouble in the switch and low tension cable is quickly made by removing the cable from the grounding terminal on the cover of the magneto interrupter housing, and then attempting to start the motor on the magneto. If the engine runs with this wire disconnected, but stops when the wire is replaced, it is evident that the magneto is in good order and that the trouble is due to some fault in the switch or grounding wire, permitting the same condition to exist as is designed and used to stop the engine by cutting out the low tension current from the breaker points.

Irregular Firing.—If the cables and plugs are in good condition and the ignition is irregular the trouble probably is with the magneto. First carefully examine the interrupter. It should be seen that the interrupter moves freely on its pivot, that the hexagonal headed fastening screw in the center of the interrupter is properly tightened, and that the two platinum interrupter contacts are properly fastened in position.

If the interrupter lever does not move freely on its pivot, which is sometimes possible, particularly with new magnetos, the hole in the fiber bushing, in which the lever pivots, may be slightly enlarged. Either a reamer or small round file may be used to remedy the trouble. The reamer is to be preferred to the file, but no matter which method is used the work must be very carefully done or the hole will be made too large. A very little reaming accomplishes the desired result.

Platinum Interrupter Contacts.—The platinum interrupter contacts should be examined for the correctness of their adjustment, and they should be so set that they separate 0.4 of a millimeter, or about one-sixty-fourth of an inch., when the interrupter lever is resting on either of the segments in the interrupter housing. The strip of steel attached to each magneto wrench is to be used for this test. A wrench is furnished with each new machine or may be purchased from the dealer.

The adjustment of the platinum points may be made by loosening the lock nut of the long contact screws, which passes through the interrupter contact block, and turning the head of the screw with the magneto adjusting wrench. When the proper adjustment is made care should be used to tighten the lock nut firmly.

The platinum contacts of the interrupter should be clean and in proper alignment with each other. Any oil or grease accumulating on them should be removed as should any form of dirt. If contacts are in bad condition, or uneven, they may be smoothed by means of a fine flat jeweler's file. The platinum contacts should be kept clean. When in that condition and given proper attention, a maximum amount of service may be expected from them. They should not be filed unless this is found to be absolutely necessary.

Removing Interrupter.—The interrupter may be taken out as a unit by removing the interrupter housing and then the interrupter fastening screw in the center of the interrupter. The magneto wrench fits this screw head. Should the interrupter stick on its seat, it may be pried loose by means of two small screw drivers inserted back of the interrupter disk, one on each side. When replacing the interrupter care must be used to have the key on the interrupter disk fit into the keyway in the armature shaft.

Damaged Insulating Parts.—As it sometimes happens that brush holders and other insulating parts are damaged through accident or carelessness, these

parts should also be carefully examined, for possible disarrangement or damage of the insulation which might permit leakage of current.

Summary of Ignition Troubles.—In brief, granting that the magneto is properly timed to the engine, trouble due to ignition may be as follows:

Engine will not start. Switch is closed, switch or switch wire short-circuited, interrupter lever sticks, defective plugs or disconnected cables.

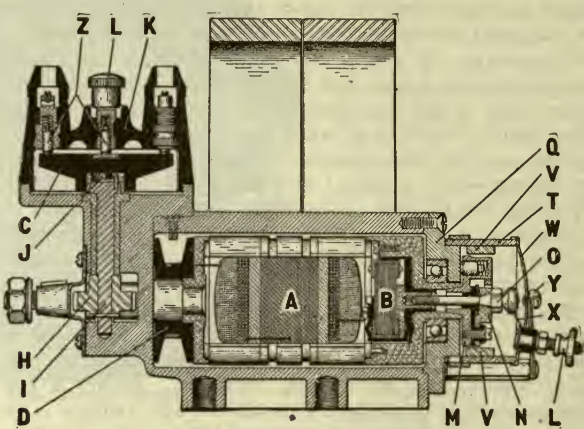


Fig. 456. Vertical Section of B4 Magneto.

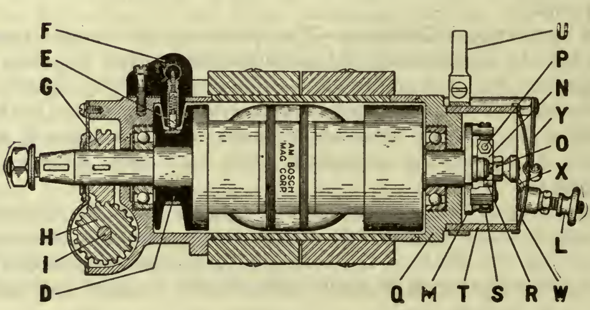


Fig 457. Horizontal Section B4 Magneto Type.

A. Armature.
B. Condenser.
C. Distributor rotor.
D. Collector ring.
E. Collector brush.
F. Collector brush-holder.
G. Armature gear.
H. Distributor gear.
I. Distributor rotor shaft
J. Shaft adapter head.
K. Distributor block.
L. Terminal nut.
M. Interrupter disc.
N. Contact block.
O. Interrupter fastening screw.
P. Contact screw—long.
Q. Rear end-plate.
R. Interrupter lever.
S. Interrupter operating spring.
T. Interrupter housing.
U. Interrupter housing control arm.
V. Interrupter cam.
W. End cap.
X. End cap contact spring with brush.
Y. Holding post spring.
Z. Distributor brush.

Engine stops abruptly. Switch is closed, switch or switch wire short-circuited.

Misfiring at slow speeds is usually due to a too wide spark gap.

Misfiring at all speeds. Spark plug may be dirty or defective, improper

spark plug gap, cable insulation chafed, cable connections loose, brush holder defective, platinum interrupter contacts dirty or oily, interrupter lever sticks.

Timing the DU Magneto to the Engine.—The crank shaft must be rotated to bring the piston in cylinder No. 1 to top dead center on the compression stroke. The piston must be maintained in that position. The magneto is then to be secured in position on its bracket on the engine. The timing control lever must be placed in retarded position. Next remove the distributor plate by withdrawing the two holding screws, or depressing the two catch springs as the case may be, thus exposing the distributor gear and brush. The cover of the magneto interrupter housing should next be removed to permit observation of the interrupter.

Next rotate the armature in the direction the engine will turn it, which must in all cases correspond to the direction indicated by the arrow on the oil cup cover. To rotate this, the distributor gear may be used. Continue to rotate the armature until the contact points are just about to separate, which occurs when the interrupter lever begins to bear against one of the cams, or steel segments of the interrupter housing.

The armature should be held in that position until the magneto drive is connected to the engine, due care being taken that the piston of No. 1 cylinder is as previously placed, exactly on top dead center of the compression stroke. The installation is completed by replacing the breaker box cover and the distributor plate. To wire the plugs proceed as follows:

Wiring Spark Plugs.—With the engine and magneto set up and connected as just suggested, the next step is to observe which brass segment in the distributor plate will be in contact with the carbon distributor brush as the points break. A high tension cable or spark plug wire is to be run from that segment, or rather from the terminal stud representing that segment to the plug in cylinder No. 1. The terminal stud next to receive a high tension current will be determined by the direction of rotation of the magneto. In all cases of gear-driven distributors this direction is just the reverse of that of the travel of the armature. Having determined which one of the terminal studs receives the second spark, the cable must be led from it to the next cylinder to be fired. The third segment in order of rotation must be connected to the third cylinder to be fired and the fourth segment to the fourth cylinder, and so on if more than four cylinders are used. Wires should be put on in workmanlike manner and carried through some form of support which will protect them from heat, oil, dirt, and accident.

JOB 137. BOSCH HIGH TENSION MAGNETO B4 AND B6 TYPES.

These magnetos with the exception of the distributor are the counterpart of the DU types previously described, and are illustrated in Fig. 459.

The cable showing on the side carries the high tension current from the collector ring to the center of the distributor from which point it is distributed to the separate cables leading to the plugs.

Fig. 458 shows the wiring diagram for the B4 type. The winding as described for the other Bosch types applies equally here. The safety gap is a threaded electrode projecting through the top of the magneto frame into the magneto just over the collector ring.

Figs. 456 and 457 are in section. The names of the parts as shown here are applicable to the other Bosch high tension types.

The placing of the distributor in the upright position is a distinct advantage

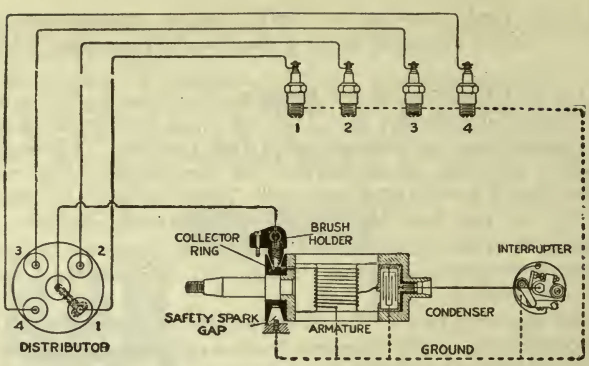


Fig. 458. Circuit Diagram Type B4 Bosch Magneto.

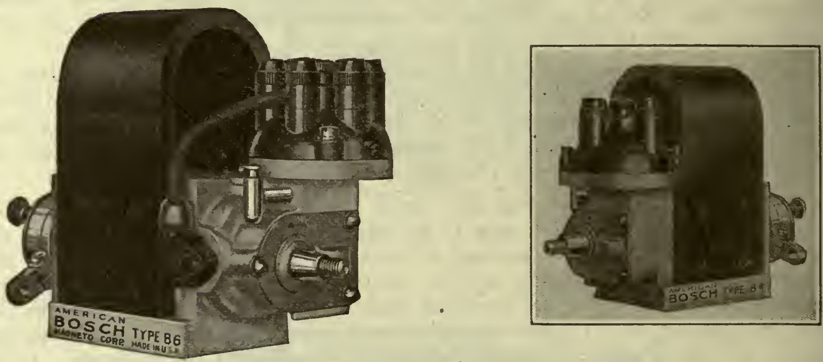


Fig. 459.
Bosch Type B4 and B6 Magnetos.

and makes for cleanliness and ease of inspection. Wiring is also simpler, since there are fewer angles to carry the wires through.

Another distinct advantage of this type over the earlier types is the unit frame construction which renders the parts fully dust and water-proof.

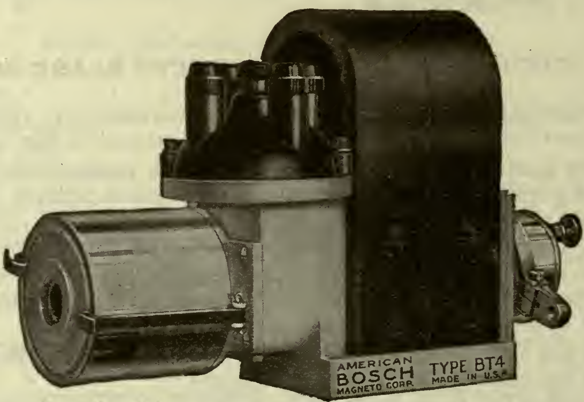


Fig. 460. Bosch BT4 Magneto with Impulse Starter.

JOB 138. BOSCH HIGH TENSION MAGNETOS, TYPES ZR4 AND ZR6.

These magnetos are for use on the four and six-cylinder engines. They are used as independent ignition. They are also used in connection with the separate battery system. The battery and magneto systems have nothing in common, each being provided with its own set of plugs, etc. The action of the magneto is closely related to the DU4 and DU6 described in Job. 136.

Primary on Low Tension Circuit.—The end of the armature primary circuit winding is in contact with the armature core. This provides a ground connection. The other end of the primary winding is connected by means of the interrupter fastening screw to the insulated contact block supporting the long platinum contact on the magneto interrupter. The interrupter lever carrying the short contact is mounted on the interrupter disk, thereby grounding it. The primary circuit is completed whenever the two platinum contacts are brought together, the magneto armature being in motion. Likewise it is broken or interrupted when the points separate. The separation of the platinum contacts is controlled by the action of the interrupter lever as it bears against the two steel segments mounted within the interrupter housing.

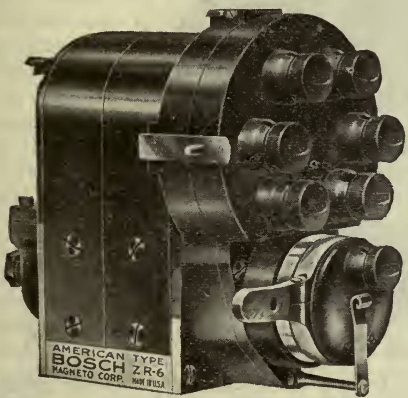


Fig. 461. Bosch ZR6 Magneto.

At the instant the interrupter points break, the collapse of the lines of force about the secondary winding is sufficiently fast to induce the required high tension current to jump the spark plug gap.

Secondary Winding.—The secondary winding is a continuation of the armature primary winding. The beginning of the secondary is connected to the primary, while the other end of the secondary is connected to the insulated collector ring, or slipring. The high tension current is taken off the slipring by the slipring or collector ring brush. The conductor bar under the arch of the magnets carries the current from the brush to the center of the distributor

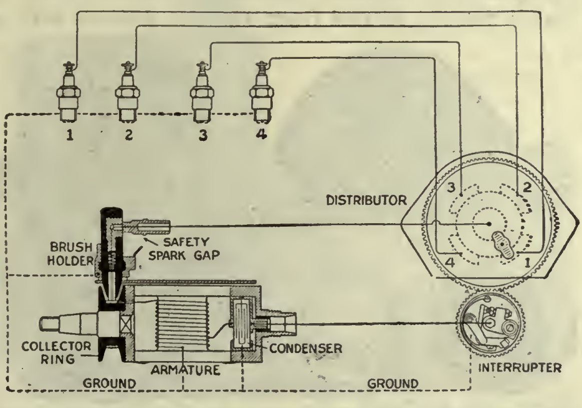


Fig. 462. Circuit Diagram Type ZR4 Bosch Magneto. Note—Spark plugs must be connected in accordance with firing order of engine.

plate. The metal brush carried by the distributor gear has one end in contact with this solid metal center. As the gear revolves, the other end is brought into contact with the first one and then another of the metal segments embedded in the distributor plate. There are either four or six of these segments depending on whether the magneto is a ZR4 or a ZR6. The segments in turn are connected with the terminals on the outside of the plate. High tension cables connect these terminals with the proper plugs.

Safety Spark Gap.—The usual safety spark gap is provided. Under normal conditions the current will follow the spark plug cable to the plug, but if for

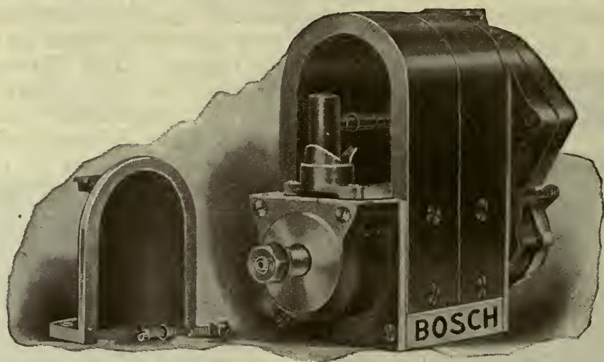


Fig. 463. Shaft end view with hood removed, showing slipring brush holder and safety spark gap.

any reason the electrical resistance in the secondary circuit becomes too great, as when a cable becomes broken, or disconnected, or the plug gap too wide, the high tension current will discharge across the safety gap.

The current should never be allowed to pass across the safety gap for any length of time. To permit this is likely to result in serious damage to the winding. The fact that it is jumping the gap is detected by the snapping sound. The gap consists of a pointed metal electrode projecting from the mounting flange of the slipring brush holder, inside the shaft end plate hood. The tip of the electrode is extended to within a short distance of the metal part of the connecting bar running between the collector ring brush and distributor plate.

Timing Range.—The magneto interrupter housing is so designed and constructed that it may be rotated from 34 to 37 degrees with respect to the

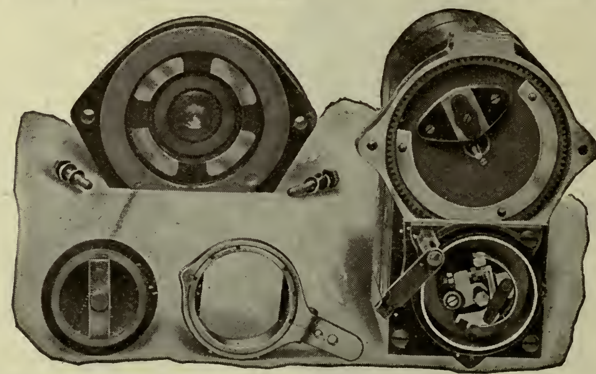


Fig. 464. View with distributor plate and interrupter housing removed showing distributor segments, distributor brush, interrupter, etc.

rotation of the armature shaft. The rotation of this housing with the direction the armature turns causes the spark to occur later or to be retarded with relation to the point the piston is in, and to the top of the cylinder at the time the spark occurs. Rotating the housing toward the turning armature, or in the direction opposite to which it is turning, will advance the spark. By this is meant that the spark will occur earlier with reference to the travel of the piston within the cylinder. A fully retarded spark occurs after the piston has passed top dead center. A fully advanced spark occurs before the piston has reached top dead center.

The arrangement for advancing or retarding the spark is in two sections. The interrupter housing and segments constitute one segment, while the timing control arm is the second part. The construction is such as to permit the timing control arm to be set in any desired position on the interrupter housing. This facilitates the adjustment for advancing and retarding the spark.

Further Instructions.—Cutting out the ignition, care and maintenance, magneto troubles, adjusting platinum points, and the installation and timing of the ZR magnetos is very similar to that of the DU types. The student should refer to Job 136 for instruction covering these and other points of desired information.

JOB 139. BOSCH NU4 HIGH TENSION MAGNETO.

This magneto is suitable only for engines of the four-cylinder automobile type, rated at or under about 30 H. P. This magneto may be used as the sole ignition or in cojunction with the Bosch Vibrating Duplex Coil, thus giving battery ignition for starting. The magneto is of the Shuttle or H armature type, the entire current generated within the armature being delivered to the spark plugs without loss or lag. The sparks so delivered are of sufficient intensity to insure the combustion of relatively poor mixtures.

The distinct gear driven distributor common to other high tension types is omitted in the NU4 magneto and in its stead is a double slipring combining the functions of current collector and distributor. The result is a considerable reduction in the number of moving parts, with a corresponding lessening of the possibilities of wear and noise. It is also of less weight. As in other types, the current is inexhaustible and is available at low speeds. The wiring is the simplest possible. Aside from the switch wire the only cables used are those running to the plugs.

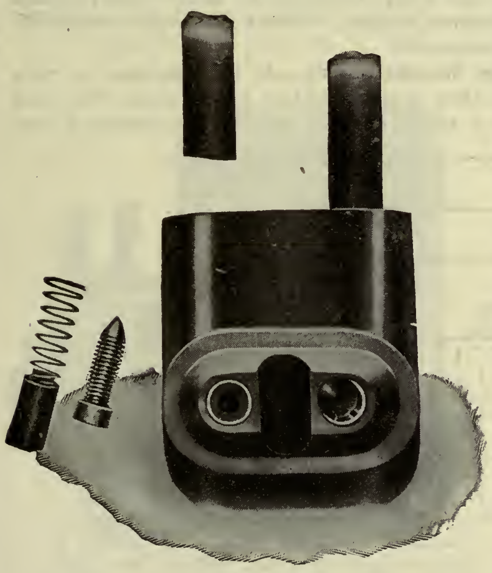


Fig. 465. View of Double Brush Holder. NU4 Magneto.

Secondary or High Tension Circuit.—The primary circuit is very similar to that of the DU magnetos described elsewhere. The secondary winding is insulated from the primary. The two ends of the secondary winding are connected to the two metal segments in the slipring mounted just inside the driving shaft end plate of the machine.

The slipring has two grooves each containing one of the two metal segments. These segments are set diametrically opposite each other, i.e., 180 degrees apart. The segments are insulated from each other as well as from the armature and magneto frame.

Four Slipring Brushes.—These brushes are part of the secondary circuit and are supported by two brush holders, one on each side of the driving shaft end plate. Each holder carries two brushes so arranged that each brush bears against the slipring in separate grooves. On rotating the armature one brush

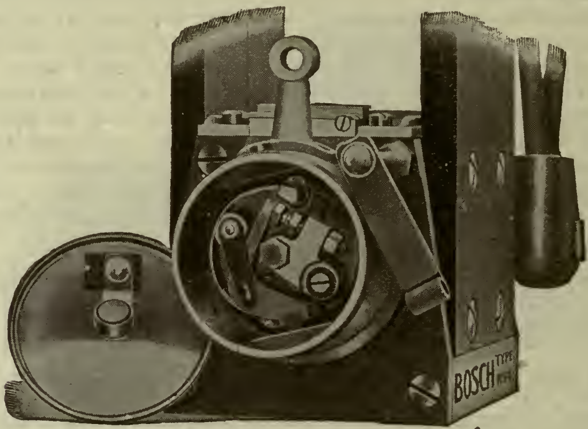


Fig. 466. Showing the Interrupter of the "NU4" Magneto.

makes contact with the metal segment in one groove, while a brush in the holder on the opposite side of the magneto makes contact with the segment in the other groove. The marks 1 and 2 appearing on the brush holders mean pairs of brushes receiving simultaneous contact. Those marked 1 constitute one pair, and those marked 2 the other pair.

A Spark Caused at Two plugs Simultaneously.—It is important to note that as two of the four slipring brushes receive contact at the same time, and as each is connected by cable to a spark plug in one of the cylinders, the

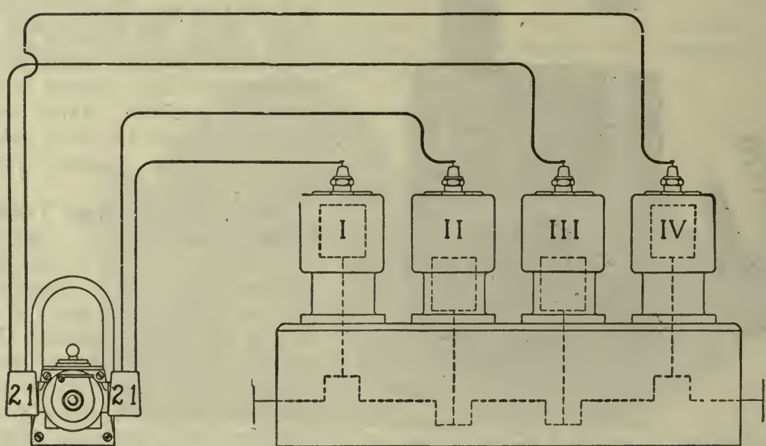


Fig. 467. Wiring diagram of "NU4".

secondary circuit always includes two plugs. The spark occurs in two cylinders simultaneously.

Timing Magneto to Engine.—It should be taken into consideration that, since at each interruption of the primary circuit a spark occurs at two plugs, the four effective sparks required for the four cylinders each two revolutions of the crank shaft are accompanied by four surplus sparks. Each cylinder

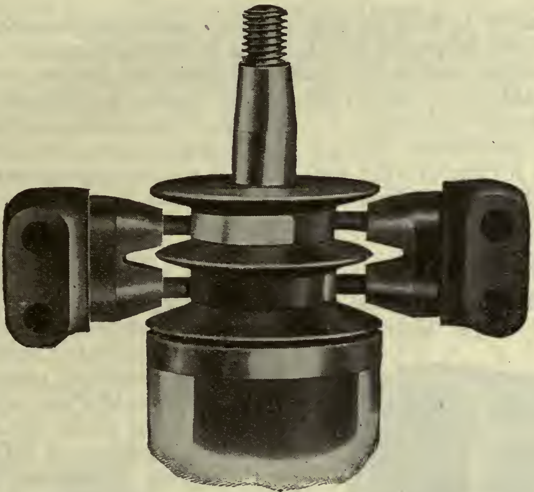


Fig. 468. Showing Position of the Slipring Brushes With Relation to the Slipring.

receives alternately one effective spark and one surplus spark, the latter occurring exactly 360 degrees behind the former.

In coupling the magneto to the engine care should be taken that the platinum points do not separate too late in their relation to the stroke of the piston. Should this happen, the surplus spark will occur after the inlet valve has opened. With the magneto correctly timed, the spark always occurs during the exhaust stroke. With the average four-cycle engine, the inlet valves of which open when the piston is at top dead center, or slightly past that position, the proper results are obtained by timing the magneto as follows:

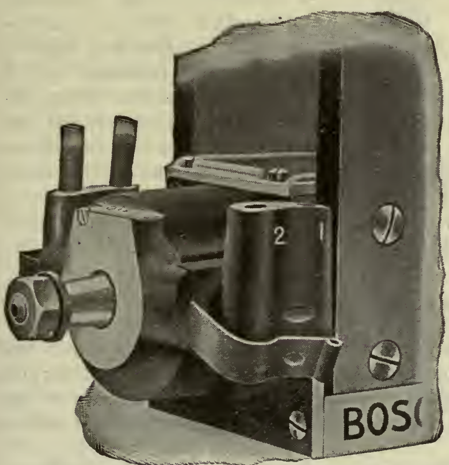


Fig. 469. Method of Removing Brush holders. With the Spring Pushed Down, the Holder Slips Out.

Piston No. 1 is brought to exact top dead center of the compression stroke. While maintained in this position, the interrupter housing is placed in retarded position. The magneto may be bolted to its seat on the bracket. Next remove one of

the brush holders, Fig. 469, to permit observation of the slipring. The armature shaft is now rotated in the direction in which it will drive until the beginning of the metal slipring segment is visible in the slipring groove corresponding to Fig. "1" of the brush holder which has been removed. Next remove the cover of the interrupter housing. Further rotate the armature until the platinum points are on the point of breaking. This point is reached when the interrupter lever bears on the steel cam or segment of the interrupter housing.

The armature is held in that position while the magneto drive is connected to the engine piston No. 1, being as formerly placed. Next carefully replace the brushes and brush holder. Replace the breaker box cover. Next connect the cable from one of the No. 1 brushes to cylinder No. 1, and the other No. 1 brush to cylinder 4. The other two cables go to the other two cylinders, that is cylinders 2 and 3. It should be noted that while these directions will care for the average four-cylinder engine, experiments will show the best timing. Frequently, instructions for timing the magneto to a particular engine are available. In this case they should be followed as closely as possible.

Attaching Cables to Brush Holders.—The brush holders fit into plates in each side of the driving shaft end plate, being held in place by the L plate catch springs. These springs are pivoted at one end, and at the other, or rounded end, carry a small boss which, when in position, rests in a notch in the brush holder and secures the holder in place. A slight downward pressure and outward pull of the rounded end of the spring disengages the spring and permits the removal of the brush holder.

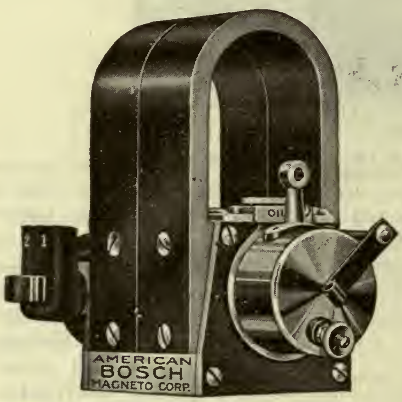


Fig. 470. Bosch High Tension Magneto Type "NU4".

To connect the spark plug cables to the magneto the brush holders are removed and the brushes withdrawn. At the base of each of the brush receptacles is a pointed cable fastening screw. Remove this with a narrow bladed screw driver. Do not force a large blade into the insulator or it will be cracked or broken. Next insert the cable end. This is cut off square and the end has no insulation removed. Replace the screws. As they are turned in they pierce the cable and make perfect electrical contact while securing it.

Troubles and Remedies.—The instruction given with reference to the DU types applies equally as well to the NU type.

JOB 140. BOSCH DUAL IGNITION SYSTEMS.

Dual ignition means not two independent sets of ignition equipment, but rather two independent sources of current. The one set of plugs, and certain other parts as the distributor and cables, are used for the application of the current from either source to work or duty of igniting the charge of fuel within the cylinder.

The Bosch Dual Magneto is of the armature type common to all Bosch instruments. It produces its own current and times it through the interrupter points and breaker mechanism. As in the independent types, the breaker

points are carried on a disk which is attached to the armature shaft. The segments which serve as cams to break the points are attached to the housing in the usual Bosch design.

In addition the dual magneto is provided with a steel cam having two projections which is built into the interrupter disk. This cam acts on a lever that is supported on the interrupter housing, the lever being so connected in the battery circuit that it serves as a timer to control the flow of the battery current through the coil. These parts are illustrated in Fig. 473.

Battery Current Units.—The student is familiar with the fact that when battery current is used in conjunction with the high tension magneto, the purpose is always to give easy starting. All induced current in any ignition system being dependent upon the rapidity with which the lines of force are cut by the winding or vice versa, it has been found impractical under certain conditions to secure a fast or high enough cranking speed to enable the operator to start the engine on magneto. Since the battery current is avail-

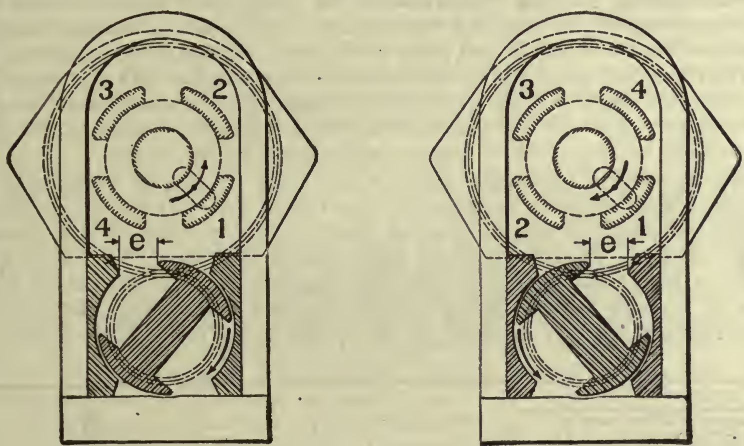


Fig. 471.

able at a uniform voltage it is used to give the initial current for starting. All units needed for battery ignition are required. All units required for the independent magneto operation are needed for running. The distributor cables and spark plugs are made use of for both systems.

It is obvious that the sparking current from the battery and from the magneto cannot be led to the spark plugs at the same time. A further change from the magneto of the independent form is found in the removal of the conducting bar between the collecting ring brush and the distributor center. Instead, the high tension current is led to the switch, and a second cable conducts the current from the switch to a terminal connecting with the distributor center.

When operating on the magneto, the sparking or high tension current flows through the switch to the distributor. When running on battery the primary circuit of the magneto is grounded, consequently no high tension current is generated. It is then that the high tension current from the coil is led to the spark plugs. This current is led from the coil to the center of the distributor on the magneto.

Bosch Synchronous Coil.—This is illustrated in detail in Fig. 474. The coil consists of a cylindrical housing bearing a brass casting which serves as a mounting flange. When the engine is running on battery ignition, a single

high tension spark occurs at the moment the contacts separate. The intensity of this spark, as well as its accurate timing, permits of operating the engine on battery current.

Switch.—The end plate of the housing carries the switch handle. The switch mechanism is built integral with the coil. By means of the switch either the magneto or the battery may be employed as the source of ignition current. In operating the switch the entire coil is rotated within the coil housing. The inner side of the stationary switch plate is provided with spring contacts that register with the contact plates attached to the base of the coil.

Independence of the Systems.—While the prime feature of the dual system is the ability to start the engine at slow cranking speeds, it is a reliable system for running in case of failure of some part of the magneto. Each system utilizes the distributor in common. This is a part seldom causing trouble or failing for any reason.

Push Button Starting Feature.—For the purpose of starting on the spark, a vibrator may be cut into the coil circuit by pressing the button which may be seen in the center of the end plate of Fig. 474. Normally this vibrator is out of circuit, but the pressing of the button brings together its platinum points and a vibrator spark of high frequency is produced. If a cylinder on the power stroke is provided with an unexploded charge of fuel, pressing of the button will give the needed spark to ignite it and thus start the engine.

Wiring the Dual System.—Refer to Fig. 472. It will be noted that while the independent magneto requires but one switch wire in addition to the spark plug cables, the dual system requires four connections between the magneto and the switch. Two of these are high tension and consist of wire No. 3 by which the high tension current from the magneto is led to the switch contact, and wire No. 4 by which the high tension current from either the magneto or coil is conducted to the terminal in the center of the distributor. Wire No. 1

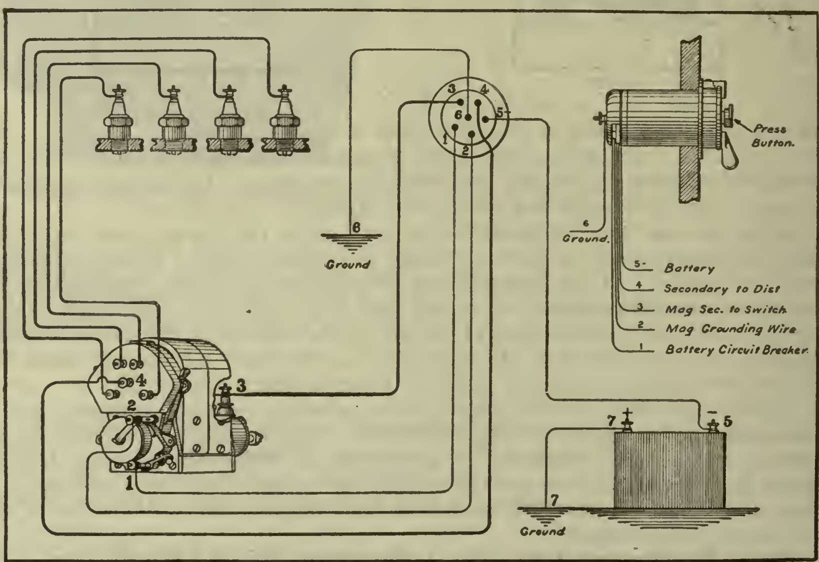


Fig. 472. Wiring Diagram of the "DU4" Dual System.
(On Magnetos of the Model 4 class, the grounding terminal is located on the side of the circuit breaker housing.

is low tension being used to carry the battery current from the primary winding of the coil to the battery interrupter. Low tension wire No. 2 is the grounding wire by which the primary circuit of the magneto is grounded. This occurs when the switch is thrown to the off or the battery position. Wire No. 5 leads from the negative terminal of the battery to the coil. Wire No. 7 is used to ground the positive terminal of the battery. A second ground wire No. 6 is used to ground the coil terminal.

Setting the DU Dual Magneto.—The Dual magneto is so arranged that the battery interrupter breaks its circuit at approximately ten degrees later than the magneto interrupter. This feature gives the full timing range of the magneto. With the timing lever fully retarded and the switch on the battery position, the battery spark will occur after the piston has reached and passed top dead center and is moving downward on the power stroke. This feature eliminates the danger of backfire.

Timing the Dual Magneto to the Engine.—The process is similar to that for the independent type. The magneto should be placed in position on the bed plate or pad provided for it, the bolts and straps being properly secured. The driving gear or coupling, however, should be left loose on the driving shaft. The instructions given in Job 136 for timing the independent type may be followed, or the following method may be used which will give the same result.

First remove the aluminum dust plate which is located under the arch of the magnets and over the armature. To remove this it will be necessary to note if spring catches or screws are used to secure it in position. If spring clips are used a screw driver may be used to spring the cover. The greatest care should be used to see that no foreign materials such as screws or washers are dropped into the armature tunnel while the dust cover is off. Next, crank the engine until the piston in cylinder No. 1 is on top dead center, compression stroke. The armature should now be rotated in the direction it will turn, clockwise or anti-clockwise until in the position shown in Fig. 471. The correct setting for the armature is determined by the dimension marked "e". For the DU4 this should be from 10 to 15 millimeters. For the DU6 the setting should be from 12 to 20 millimeters. These settings represent an advance of from 10 to 15 millimeters on motors with 130 millimeters stroke.

With the armature held in this position and the crank shaft and pistons as placed, the magneto coupling may be secured. It is difficult to give the exact setting. This is often determined by experiment after the approximate setting has been found as above.

Setting the ZR Dual Magneto.—In this case it is unnecessary to remove either the interrupter housing cover or the distributor plate in order to determine the setting of the instrument, or to locate the distributor terminal with which contact is being made. First fasten the magneto in position allowing the coupling to remain loose. Bring piston No. 1 to firing position for full advance. The fly wheel markings, or the engine manufacturer's instruction book may give this. Next rotate the armature until the Fig. 1 can be seen through the window in the face of the distributor plate. The cover of the oil well on the distributor end of the magneto is then to be raised and the armature is to be rotated a few degrees in either direction until the red mark on one of the distributor gear teeth is brought into register with the red marks on the side of the window located between the two oil ducts. The magneto is then in time for the full advance position, and since the engine has been maintained in that position the two may be connected.

Dual Coil Care and Use.—When a four-cylinder engine comes to a stop it is very likely to stop with the crank shaft in a horizontal position. The

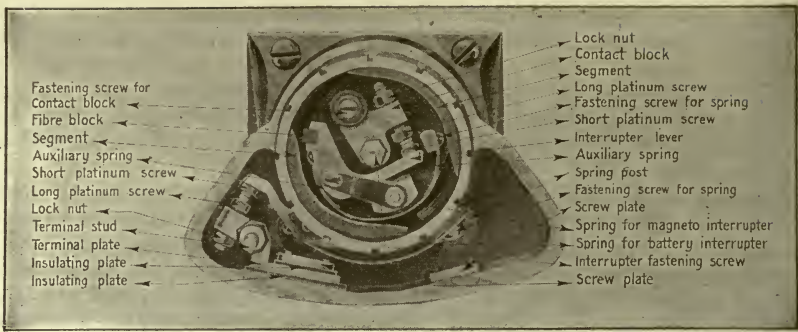


Fig. 473. Interrupter and Battery Timer for Type "ZR4" Dual.

pistons are at the midpoint of their stroke. At this position of the crank shaft the battery contact points are open. As the battery interrupter and coil vibrator are in parallel, a pressure on the starting button of the coil will close the battery circuit through the battery and primary winding of the coil. As this current is broken, the high tension spark is induced in the usual manner. The distributor brush at that instant will be in contact with the distributor terminal which is in connection with the spark plug in the cylinder on the firing stroke. The ignition of the charge within this cylinder will follow. If, for any reason, the engine comes to a stop with the pistons on the end of their strokes, the push button starting will not be possible since the primary circuit is already in the circuit through the battery interrupter, and no break of this primary circuit can be effected. Consequently no high tension current can be induced.

Vibrating Coil and Plain Coil Combined.—For ordinary starting conditions the push button should be set to the position marked "Run". This will give a single hot jump spark similar to that common to standard battery ignition. This spark is dependent on the break of the battery interrupter points. However, if difficulty is experienced in starting, the vibrator may be used to secure a shower of sparks similar to the vibrating coil described in Chapter 11. To utilize this feature of the coil the push button should be pushed down or in, and then turned to the right to the "Start" position. This locks the vibrator in circuit and a shower of sparks is produced instead of the single one. This method should be used only for starting on a poor mixture or when the motor is cold.

Battery.—The standard dual coils are wound for a battery current of six volts. Either storage or dry cells may be used. Each coil is wound for a certain voltage, and if this is not exceeded the platinum points will not require much attention. This voltage is stamped on the coil. If dry cells are used the number should be ten for the four-cylinder engines and twelve for the six-cylinder engines. Multiple series connections should be used, having two groups of five or six cells in each group.

Detecting General Trouble in Ignition System.—In the event of failure of the ignition system it should first be determined which side of the system is at fault. It may be both. This may be determined by throwing the switch from one side to the other. If there is a continual miss on one cylinder on the magneto as well as the battery, the fault usually lies in the spark plug. This will likely be due to fouling, breaking, or improper gap. If a failure is found in all cylinders on the battery as well as on the magneto, the fault is due to a

short circuit due to failure of insulation of the cables, to improper contact, or to the grounding of the terminals. This fault may also be due to broken cables. High tension cables Nos. 3 and 4 should be tested.

Detecting Dual Magneto Trouble.—If the switch shows the magneto to be the side at fault, all cables and terminals should be examined for poor or wrong connections. The coil and battery system may then be disconnected by removing the wires from terminals Nos. 3 and 4 of the magneto, and connecting 3 directly to 4 with a short piece of wire. This will conduct the high tension current from the collector ring to the center of the distributor. Next, disconnect the grounding wire from terminal No. 2 of the magneto. With this arrangement it should be possible to start the engine on the magneto. If something has happened to the coil this method must be resorted to.

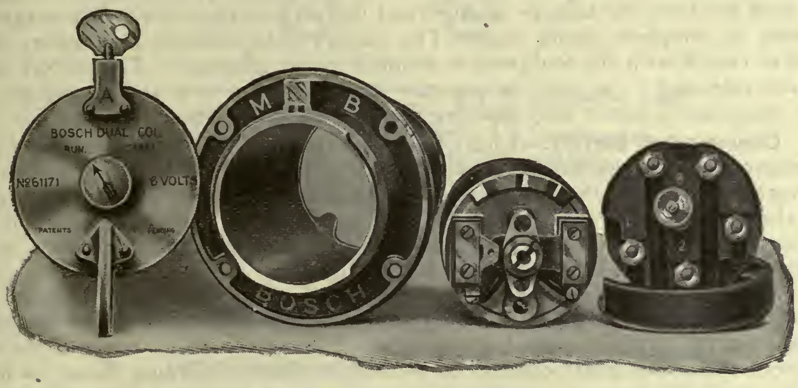


Fig. 474. Parts of the Coil.

To ascertain if the magneto is generating current, the wire should be disconnected from terminal No. 2 on the magneto. Next disconnect the high tension wire No. 3 from the collecting ring terminal. If the engine is then cranked briskly the magneto should show a spark at the safety spark gap located under the arch of the magnets on the dust cover. If no spark is shown at the safety spark gap the trouble may be a leakage or loss of the low tension current. This might be caused by chafed insulation, incorrect connections, or an injury to the switch parts.

Detecting Battery System Faults.—If the engine misses on the battery but operates well on the magneto the fault will usually be found within the battery itself, the voltage having dropped too low. Should the battery show the proper voltage, the battery interrupter should be examined to observe whether the lever moves freely. The points also must be clean and properly adjusted. These points are kept just a trifle wider than the magneto interrupter points.

The coil should not be dismounted unless this is first found by tests to be absolutely necessary. To test the coil first disconnect wire No. 4 from the magneto and throw the switch to the battery position. Hold the terminal on the end of wire No. 4 a slight distance from the engine or some other metal ground and operate the push button. A brilliant jump spark will be seen if the coil is in good condition. If the spark does not appear, repeat the test with wire No. 3 disconnected. Failing to get a spark under this test it may be necessary to remove the coil. To do this, first remove the holding screw which is located close to the supporting flange. The switch should then be unlocked and the end plate given a quarter revolution. This will release the bayonet

lock and the coil body may then be withdrawn to permit the inspection of the switch contacts both of the coil and the stationary switch plate. It is possible that the spring contacts are bent or otherwise in bad condition. The withdrawing and subsequent handling should be performed with extreme care. Further tests for ignition coils are given elsewhere.

JOB 141. BOSCH DUPLEX IGNITION SYSTEM.

The Bosch Duplex Ignition System is so designed as to offer a simple method of starting the engine at low cranking speeds. A battery is used in conjunction with the Duplex Ignition Coil and a standard high tension magneto arranged for duplex ignition. When so arranged the magneto is known as a duplex magneto. The duplex coil is low tension only. The same set of plugs is used for both the battery ignition and the magneto ignition. The magneto circuit is complete within itself. The battery side includes the battery and coil in circuit with the low tension winding of the armature. The battery side is not intended to be used as separate ignition but merely as an auxiliary to the magneto to insure easy starting at slow cranking speeds.

Operation of Battery.—Under this condition the switch is so arranged in conjunction with the wiring of the magneto as to include the low tension or primary winding of the magneto in circuit with the duplex coil. The action of the battery is to supplement the normal action of the magneto which, at extremely slow speeds, does not generate enough current to induce a high tension spark when the breaker points are opened.

Since the magneto generates an alternating current which changes its direction of flow every 180 degrees revolution of the armature, some changes from the independent high tension type magneto are necessary. While the battery current is direct current, to be held in phase, (meaning to act or flow with), with the magneto current it is necessary to provide a commutator on the magneto. To this end a simple form of commutator is fitted on the inner surface of the interrupter housing cover. The commutator is not designed to change the direction of flow of magneto current, but rather to change the direction the battery current flows through the armature low tension winding. This causes the battery current always to flow in the direction of the current being generated within the magneto. Each current, battery and magneto, then change the direction of flow each half revolution of the armature. With the starting of the engine, and at the lowest speeds at which it is possible to operate the engine, the magneto will generate enough current within the primary winding to induce current within the secondary winding for the high tension spark. After the engine has started, the ignition is equally efficient whether the switch is left on the battery side or turned over to magneto. However, in order to reduce the drain on the battery it is best to throw the switch to magneto immediately the engine has started.

Operation on Magneto.—When the switch is thrown to magneto position, the battery connection is interrupted, and the operation of the magneto is identical in every way with the operation of an independent magneto. It should be noted that the battery and duplex coil are employed in the battery circuit only and not in the magneto circuit. The removal of either the battery or coil would interfere not at all with the operation of the engine on magneto, but the difficulty is in starting at slow cranking speeds directly on the magneto.

Bosch Duplex Magneto.—Aside from the interrupter and interrupter housing described herewith, the construction of the duplex magneto is identical with the corresponding independent high tension types.

The interrupter housing consists of a fiber disk which is maintained in

fixed relation to the housing by a key fitted into a keyway. The inner surface of the disk is provided with two metal segments as shown in Fig. 475. Each of these segments has an external terminal for connecting it in circuit. The interrupter is provided with two brushes which make contact with the metal

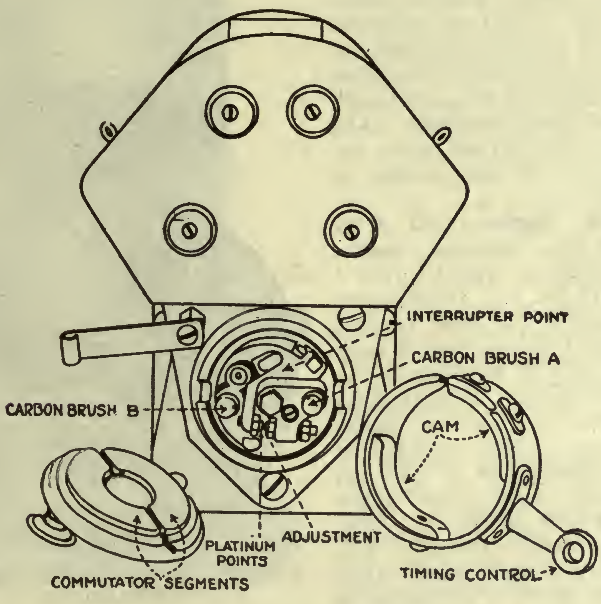


Fig. 475. "DU4" Duplex Magneto partly disassembled.

segments on the cover as the armature is turned. These two brushes together with the commutator might be compared with the Simple Direct Current Motor shown in Fig. 278. However, in this case the commutator serves to convert D. C. current into A. C. current instead of A. C. to D. C. as in the illustration. The reversal thus provided for is necessary to hold the battery current in phase with the magneto current, as indicated previously.

Switch and Coil.—These units are built together. The coil is a simple primary winding. It is fitted with a push button and vibrator points for push button starting. The coil is not likely to give any trouble. In case of the removal of any connections, care must be used to have them replaced correctly. If the battery is so connected to the coil and magneto that the two currents are not in phase, they will buck one another as soon as the engine is started and the magneto primary winding starts generating its own current. This will result in stopping the motor. To correct this trouble which is evidenced by the engine stopping almost immediately it is started, it is only necessary to put the two currents in phase by changing the battery wires either at the coil or at the battery.

JOB 142. BOSCH VIBRATING DUPLEX IGNITION.

The Vibrating Duplex Ignition System is designed to reduce to a minimum the effort required to start magneto equipped engines. The complete ignition system operates on one set of plugs. It consists of a standard high tension magneto,

a low tension vibrating coil, and a control switch together with the battery and necessary wiring.

Magneto.—The standard Bosch Independent High Tension magnetos are used. These are described in Job Sheets Nos. 136, 137, and 138. Any questions arising concerning their care, operation and timing are cared for under these headings. The construction, care and use of the duplex vibrating coil are treated in this job sheet.

Fig. 476. Bosch Vibrating Duplex Coil, VD Ed. 1.

Vibrating Duplex Coil Construction. — The vibrating duplex coils are known as type VD Ed. 1 and type VD Ed. 2. The housing is in two parts, the base part so arranged that it may be held in position on the dash or floor board, the other so arranged as to permit its being removed to adjust or inspect the coil proper. This construction completely housing as it does all parts, protects them from injury and prevents dirt, grease, etc., from entering to make trouble. The flanged section of the housing carries the coil base which is of insulating material. The iron core of the coil is H shaped and is mounted on the base. The insulated wire forming the winding is wound about the H core. One end of the wire is grounded onto the core, while the other end is connected to one of the two outside terminals of the coil.

VD Ed. 1 Coil.—In this case the iron core is threaded at its upper end to receive the vibrator cover, the closed end of which carries the insulated adjustable vibrator screw, with a platinum contact projecting on the inside of the cover. A second vibrator contact is mounted on one side of a wide, flat spring, the other side of which carries a soft iron button. This arrangement constituting the vibrator assembly is mounted on the inside of the vibrator cover in such a way that the soft iron button faces the coil winding and the two vibrator contacts meet. The adjustable vibrator screw is connected by means of a short wire to the second outside coil terminal.

VD Ed. 2 Coil.—In this type the vibrator cover is not used. The vibrator, consisting of the vibrator spring, platinum contact and soft iron trembler button, is mounted upon and supported above the pole shoes in such a way that its platinum contact is in contact with the platinum of the adjustable vibrator screw. The screw in this case is carried by a bridge mounted above the pole shoes. This is shown in Fig. 477. As in the other type the adjustable contact screw is connected to the second outside terminal screw.

Condenser.—In order to reduce the wear on the platinum contact points and to produce the further proper action of the coil, a condenser is provided. The action of the condenser is described in Chapter 10 and again in Chapter 12. The condenser is mounted on the iron core of the coil opposite the base.

Principle of Coil Operation.—The battery current, upon reaching the coil terminal with which the coil winding is connected, passes through the winding

to the iron core, thence to the flat vibrator spring with its contact, then to the adjustable vibrator screw, and finally out of the coil by the second terminal.

Fig. 477. Bosch Vibrating Duplex Coil, VD Ed. 2.

When the complete battery circuit is established, the coil winding by reason of the current passing through, acts as an electromagnet, alternately attracting the iron button on the flat vibrator spring. The first action interrupts the battery current and the second re-establishes it. These actions follow each other in such rapid succession that they give rise to a continuous vibration or buzz which lasts as long as the switch is in battery position.

The coil is so constructed that it may be used in conjunction with circuits of from six to sixteen volts. This permits of the coil being used on any of the batteries ordinarily employed for starting and lighting service.

Wiring Directions. — Refer to Figs. 478 and 479 for the wiring diagrams. It should be observed that all cables excepting the spark plug wires are primary or low tension wires. Where the coil is used with the two-wire or insulated return system the connections for the type S17 switch should be in accordance with the wiring diagram shown in Fig. 479. One low tension cable from the negative battery terminal is run to one terminal of the vibrating coil. A second low tension cable is run from the other coil terminal to the switch terminal marked "Coil." A third low tension cable is run from Mag. on the switch to the grounding terminal on the magneto interrupter housing. A fourth one is run from the switch terminal marked Grd. to a grounding point

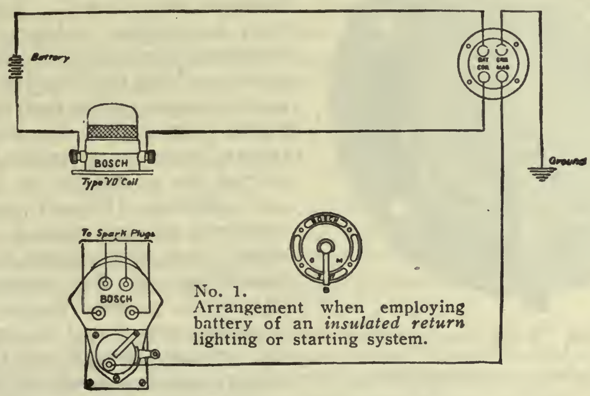


Fig. 478. VD Coil Wiring Diagram.

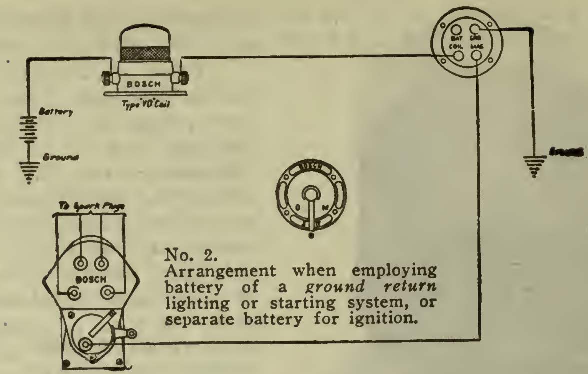


Fig. 479. VD Coil Wiring Diagram.

on the engine or car frame. The fifth and final cable is run from the switch terminal Bat. to the positive terminal of the battery.

Where the system is used with a single wire, or ground return starting and lighting system, or where the battery is used solely for ignition, the switch and battery connections will be the same as for a two-wire system with one exception. The positive terminal of the battery is to be grounded while the terminal marked Bat. in back of the switch is to be left free. The complete connections for this arrangement are shown in the wiring diagram Fig. 478.

Operation of System on Battery.—The primary circuit of the magneto is included in the battery circuit. This is in series with the battery and the coil. The purpose of the battery is to supplement the current generated within the magneto at slow cranking speeds.

With the switch in the battery position, current from the battery passes through the vibrating coil to the insulated magneto grounding terminal, the inner end of which is in contact with the head of the magneto interrupter fastening screw. The interrupter fastening screw, in turn, is connected with the end of the armature primary circuit, so that when the magneto interrupter contacts are open, the battery current passes through the armature primary circuit to its beginning or grounded end, thence returning to the battery through the ground. When the magneto interrupter contacts are closed, however, the current from the battery, after reaching the interrupter fastening screw, passes to the interrupter contact block, then across the magneto interrupter contacts to ground, thus completing the circuit to the battery without passing through the magneto armature primary circuit. When the switch is in the battery position, each separation of the magneto contact interrupter points throws the current from the battery and vibrating coil into the primary circuit of the magneto armature, thereby supplementing the current generated within the magneto through the rotation of the armature in the magnetic field. This induces in

Fig. 480. Bosch Switch.

the secondary circuit of the magneto armature a very high tension sparking current. This sparking current on account of the action of the coil appears not as a single spark but a series of intense sparks. The student will readily see the benefits derived from having this intense shower of sparks flowing between the spark plug points when the engine is being cranked over slowly. With a mixture anywhere near correct the engine is almost certain to be started. The sparking, or high tension current, is distributed in the usual way through the magneto distributor. The battery side is not intended as a separate ignition system.

Coil Care and Adjustment.—The only parts of the coil subject to wear are the platinum vibrator contacts. First remove the coil cap. Next loosen the hexagon lock nut and then slightly advance the contact point on the adjustable screw by screwing in on it. This brings the platinum points into contact with each other and compensates for any wear which may have occurred. This adjustment need be made only once or twice a season at the most. After considerable service it may be necessary to remove the screws and points for inspection and repair. To put them back in condition a very fine jeweler's or platinum point file is used. Other than this the coil requires no care. In case of serious trouble it may be tested as indicated for coil tests, Chapter 12.

Troubles, Cause and Remedy.—Since the coil is made to operate in conjunction with the magneto, faults due to the magneto will appear on the battery side as well as the magneto side of the system. When testing for troubles it is always well to start and operate the engine on the magneto side independent of the battery side, if that is possible. To make this test independent of the coil, it is necessary only to remove the low tension wire leading from the battery to the coil. Refer to the jobs covering Bosch High Tension Magnetos for a digest of magneto troubles.

So far as the battery side is concerned there is very little to get out of order. Practically the only parts likely to get out of order are the platinum points and these are so protected by the condenser action that they require attention at infrequent intervals.

Failure of Coil to Vibrate.—If, with the switch on the battery side, the coil fails to vibrate when the switch is in battery position the first unit to suspect of failure is the battery. The voltage may have dropped to a point too low for the proper operation of the coil. The second point to investigate are all low tension wires and terminals. The terminals may have worked loose. Again, the motor may have, through its vibration, caused one of the cables to become chafed and produced a short circuit. A cable may even be broken within the insulation and not be revealed in a casual inspection. An interruption to the battery circuit would also result if the contact points failed for any reason to come together. This fault is remedied by bringing the points together as described in the previous paragraph. In case the coil does fail to vibrate, there is no reason why the engine may not be operated on the magneto, if sufficient cranking speed can be attained. If the engine does operate on the magneto, but will not start on the battery, it is a certain indication that the current from the battery, wiring, or the coil is at fault. Should the battery side be in order and enable the engine to be started, but fail to operate on the magneto, the difficulty will be found to be due to the magneto interrupter contacts not opening sufficiently, or to the plugs having too great a gap.

If the coil vibrates and the engine fails to start, the next point to investigate is the gas supply. If the carburetor is correct and the engine still fails to start, the wire leading from the coil to the magneto may be at fault. Again, the fault may lie with the magneto points failing to open. If the trouble

is not found in these two points, inspect the magneto grounding terminal for a short circuit. Any of these conditions permits of the battery current escaping to ground without passing through the magneto primary circuit. If no current flows here, the main purpose of the vibrating duplex system has failed and no high tension current will be induced within the magneto secondary circuit.

JOB 143. BOSCH ADJUSTABLE IMPULSE STARTER COUPLING.

To facilitate the starting of heavy duty motors such as are used in the larger trucks and the tractors, the Bosch Adjustable Impulse Coupling has

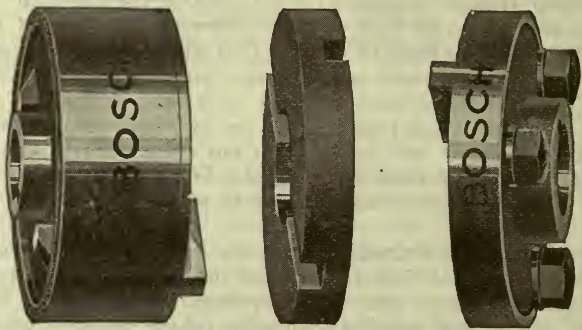


Fig. 481. Type CG-83 Coupling Partly Disassembled.

been developed. The usual method of equipping the engine with some auxiliary battery ignition system for starting at slow cranking speeds is thus displaced. The essential feature is a spring device which is so fitted to the magneto that it will give the armature a short quick turn when the engine is cranked over at

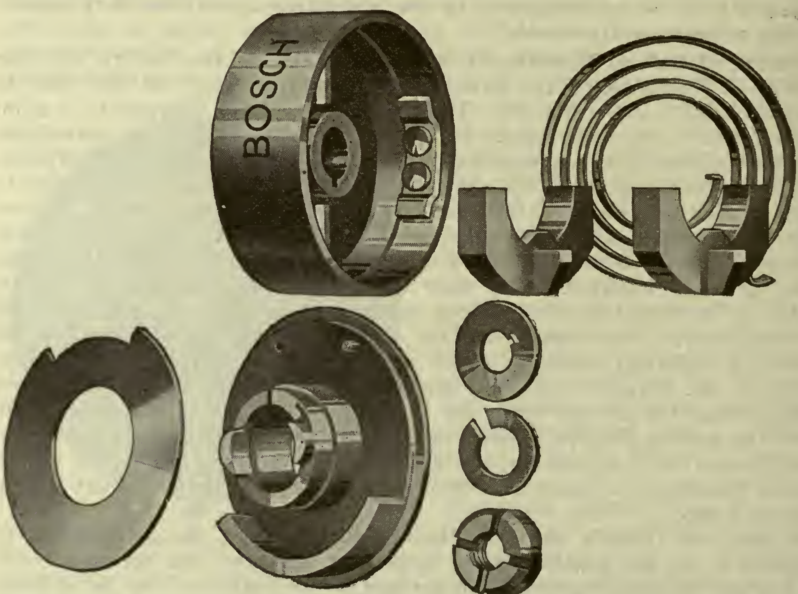


Fig. 482.

slow cranking speeds. The device is so designed and constructed that it is automatically disconnected when the engine attains a speed of from 160 to 180 R. P. M.

Construction and Design.—The coupling is designed in three main parts, each having functions to perform peculiar to it. These three members are: the impulse member, the driving disk, and the adjustable drive member.

Impulse Member.—As noted in the illustrations, this member consists of a hardened steel housing, which is mounted directly on the drive shaft of the magneto. Inside of the housing are two governing or arresting weights which may move in and out guided by tongues on their rear which fit into slots in the inner face of the housing. When the coupling is turned slowly, the tongues of the arrester weights alternately engage with a small steel block that is mounted on the arrester plate. This arrester plate is mounted on a fixed position on the frame of the magneto and does not revolve. A steel spring acts as a connector between the housing and what might be termed its cover which is known as the driving flange. One end of the spring is held in the outer edge of the housing while the other is held in the hub of the driving flange. The hub of the driving flange carries two cams which lift the arrester weights at the proper instant, thus releasing the spring.

Operation of Impulse Member.—When the engine is cranked the impulse member is in its normal position. The tongue of one of the arrester weights will be resting against the arrester block, thus holding the housing stationary. As the engine is cranked over, the driving flange revolves, thus winding up the spring since the housing is, as just stated, held stationary. At a fixed point one of the cams of the driving flange lifts the arrester weight clear of the arrester block, the wound spring thus released. The impulse coupling housing which is mounted on the armature shaft is thus given a quick turn. This causes the magneto to develop and deliver an intense spark to the cylinder in firing position. With the engine running, the centrifugal force developed at 160 to 180 R. P. M. is sufficient to throw the weights in the coupler housing to its outer surface where they are held by the same force. Above these speeds there is no further action of the impulse member parts, the whole unit revolving and transmitting the driving effort much the same as any other magneto coupling. When the engine has been stopped the weights are immediately

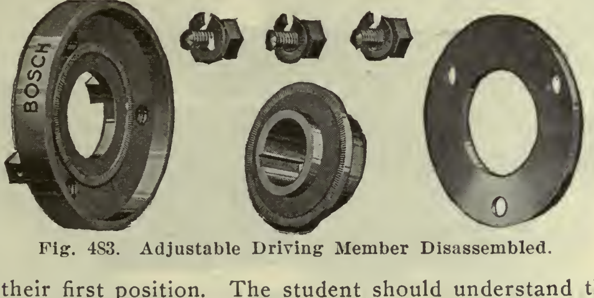


Fig. 483. Adjustable Driving Member Disassembled.

returned to their first position. The student should understand that it is not the speed of the cranking operation which governs the speed of the magneto armature action, but rather the strength of the uncoiling spring which controls the armature speed. As a consequence the spark delivered by the magneto is as hot or intense as that which is delivered when the engine is operating at a speed of several hundred revolutions per minute. There is no danger of back-fire from the use of the impulse starter coupling, as the adjustment is such that when cranking the spark occurs always after the piston has passed T. D. C.

The Adjustable Driving Member.—This member is made of hardened steel

throughout. The outer face of the keyed flange carries two keys which fit into slots on one side of the driving disk. The inner surface is knurled as is the inner surface of the driving hub which fits into and against it. These two parts are held together by means of the holding plate and three cap screws. This construction permits of the fractional degree adjustment so essential to exact magneto-to-engine timing. To adjust the driving member the cap screws should be turned part-way out until the hub is shown to be loose within the driving flange. The driving flange may then be advanced or retarded on the hub as desired and the whole locked together as one unit again by tightening the three cap screws. Be certain to keep the lock washers in place on these.

Care and Maintenance.—In case it should be necessary to disassemble the coupling, it can be done readily if some care is used. When removing the magneto from the engine the adjustable coupling will remain on the engine while the driving disk will be loosened and laid away. The driving flange may now be removed from the housing of the impulse unit by pulling it away from it. Use care that the spring does not fly out. Never use a grease to lubricate the impulse unit. Use a good thin oil only as the grease will harden and interfere with the free action of the weights.

JOB 144. EISEMANN HIGH TENSION MAGNETO G4.

The G4 type of Eisemann magneto may be considered as basically representing the complete line. Certain features of difference will be noted in the description of the other types under their respective job sheets.

Generation of Current.—The magnetic field is created and maintained by two horse-shoe magnets. These are mounted on the pole shoes. The armature driven at engine speed is mounted between the pole shoes. Ball bearings are used to carry it. The armature is of the H or double T type. It has a combined winding, primary and secondary. When rotated within the field, a low tension current is induced within the primary winding. When, at the moment of greatest intensity, this circuit is broken by the opening of the contact breaker points, this break causes the rapid collapse of the magnetic lines of force about the core of the armature. This in turn results in the induction of a high tension current within the secondary winding which is used to jump the plug gap and ignite the fuel charge within the cylinder. One end

Fig. 484. Eisemann High Tension Armature, H. or Shuttle Type.

of the secondary winding is connected to the collector ring from which the current passes to the distributor and thence to the plugs.

Armature.—The armature core is made up of two end pieces of soft malleable iron, between which are a number of insulated soft sheet steel

laminations. The parts are riveted together in such manner that the core is one solid unit in appearance. The primary winding of a few layers of medium-sized copper wire has one end grounded to the armature core, thus making connection with the contact breaker mechanism which is also grounded. Over this primary winding are wound many turns of very fine copper wire. The wire used is insulated and these several layers are each insulated from the ones above or below it. The beginning of the secondary is connected directly to the end of the primary winding, while the end of the secondary is led to the collector ring with which it makes electrical contact. This arrangement grounds the secondary winding through the primary winding ground.

Condenser.—The condenser which is built in at one end of the armature, prevents a spark occurring at the opening of the contact breaker points. Without the condenser, the contact points would be burned and pitted very quickly. It also increases the intensity of the spark at the plugs. The illustration of the Eisemann Armature shows the method of mounting and protecting the condenser. This illustration also shows the windings, the collector rings, the bearings, and the gear driving the distributor gear.

Contact Breaker.—This part is so-called because the separation of the

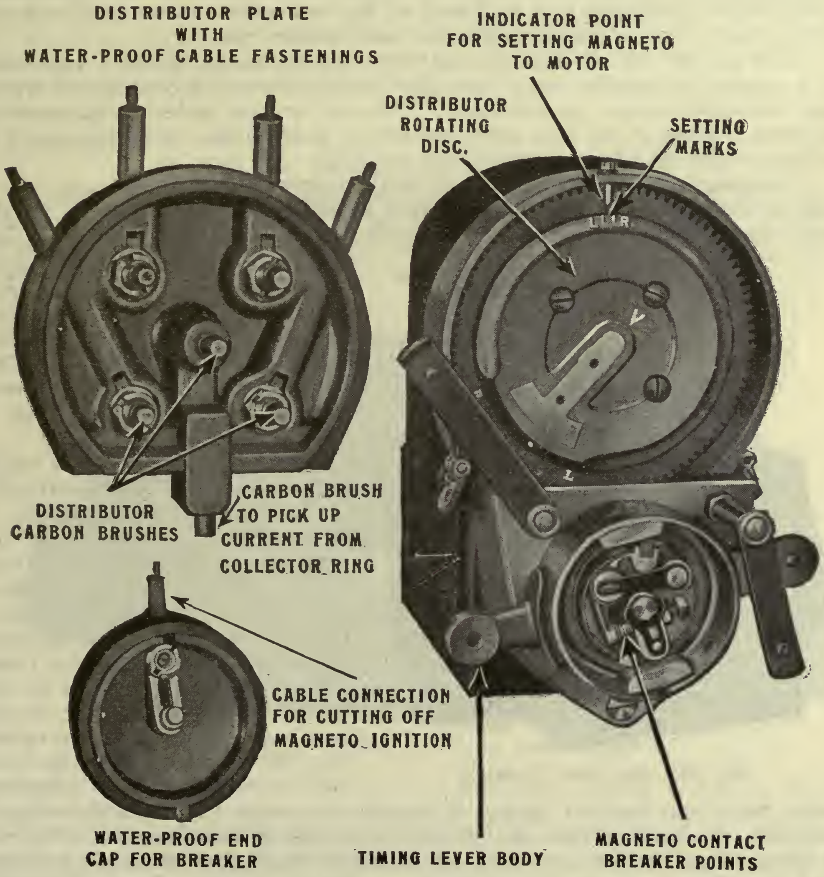


Fig. 485. Disassembled view of Eisemann G4 Magneto.

platinum contacts breaks or interrupts the primary circuit. The contact breaker is shown in Fig. 485. A brass disk fastened in the end of the armature carries the mechanical and electrical elements of the breaker on its face. Mounted on this face is a stationary insulated contact block. The contact block carries the fixed contact point. Electrical connection is made from the block to the primary winding end by means of the screw holding the entire breaker in place. Operating against this fixed contact is another platinum contact mounted on a bell crank lever or rocker arm. This lever is operated by riding over two flat steel cams mounted in the timing lever body. The contacts are normally held in a closed position by a flat steel spring. The moving contact is also grounded through this spring. To maintain the breaker mechanism in proper time with the engine and armature position it is set by a key formed on its conical part. The key is fitted into a key way in the armature. If for any reason the breaker is removed the key and key way must be carefully fitted together when it is replaced.

Distributor.—A brush in the distributor plate receives the high tension current from the collector ring. Refer to Fig. 485. This center brush makes contact with the T shaped metal insert of the distributor disk. The disk is attached to the distributor gear and rotates with it. As it rotates the metal insert makes contact in turn with each of the carbon brushes on the distributor plate which are in connection with the spark plug wires.

The proper fastening of the cables to the distributor plate is important. If not properly installed water may short circuit them. All connections are on the inside where they are protected. The high tension cables are fastened by winding the end of the wire about the carbon brush holder, and clamping it in position with the hexagon nut.

Housing.—The housing is of unit cast construction. The iron pole shoe is cast in non-magnetic metal. This makes a compact and rigid housing for the vital elements where they are certain to be maintained, free of water, dirt, oil, and other foreign elements, in their proper position. Since the housing can be machined as one piece, closer fits between the armature and pole shoes are possible. This tends to give better operating conditions for the magneto and a hotter spark.

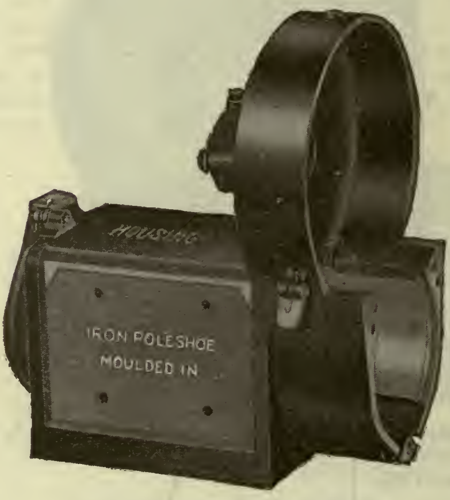


Fig. 486. Unit Cast Housing.

Spark Control.—As the spark occurs only when the primary circuit is broken by the opening of the contacts, the timing of the spark can be controlled by having these contacts open sooner or later with reference to the fly wheel travel or top dead center position of the pistons. The timing range is 30 degrees accomplished by the angular movements of the timing lever body. The spark is retarded when the movement is in the direction of rotation, and advanced when the timing lever is pushed in the direction opposite to the direction of rotation. In fixed ignition the timing lever body is not equipped with controlling arms. In this case it is set at the point of greatest spark intensity and any advance or retard must be of a permanent nature. By this is meant

that the spark is set to occur at a fixed position of the piston travel, whether the engine speed be fast or slow. The only change of setting possible with relation to the engine is by making a change of the timing with the engine. This must be done with the coupling, if that is adjustable, or with the magneto shaft timing gear drive on the engine by advancing or retarding the gear a tooth or so.

Timing the Magneto to the Motor.—First remove the distributor plate having the magneto bolted in position with the coupling free. Next bring the setting mark on the distributor disk to the indicator point by rotating the armature by hand. For magneto rotating clockwise use setting mark R. For magneto rotating anti-clockwise use the setting mark L. With the armature in this position the points are just separating, and the metal insert is in contact with the carbon brush for cylinder No. 1. Next, bring the piston in cylinder No. 1 to top dead center, compression stroke. The magneto and the engine drive shaft may now be connected using some form of flexible coupling. Use extreme care to maintain the magneto and engine in proper position until this work is accomplished.

Safety Spark Gap.—Should the spark cable become disconnected or broken, or should the plug gap be too wide, the high tension current in attempting to find a ground may puncture the insulation of the armature or other parts. The safety gap consists of a pointed screw placed in the housing at a certain distance from the collector ring. The high tension current, failing to find its usual path to the plugs available, will pass from the collector ring to this screw and is thus grounded.

JOB 145. EISEMANN MAGNETO GA 4.

Automatic Spark Advance.—This magneto is the same general type as the standard G4 with the addition of the automatic spark advance. The automatic spark advance is accomplished by the action of centrifugal force on a pair of weights at one end linked to a sliding block. This block is fitted over the

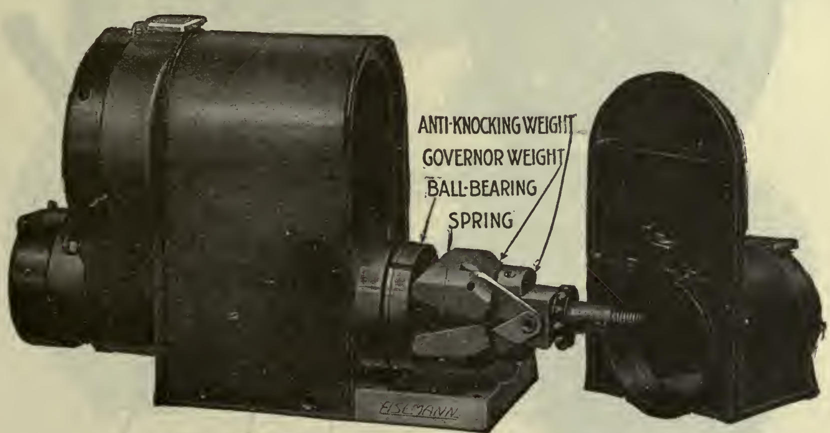


Fig. 487. Eisemann Automatic Spark Advance.

spindle of the magneto. The other end of the weights is hinged to the armature structure. Along the armature spindle run two helicoidal splines which engage in similarly shaped grooves in the sliding block. A coil spring pressing against this block keeps the governor normally closed, when the motor is running slowly. In this position the spark is fully retarded.

As the engine speeds up, the centrifugal force causes the governor weights to spread out, drawing the sliding block lengthwise against the spring and compelling the helicoidal splines to cause angular displacement of the block. This action advances the armature relative to its former position on the shaft and as a result of this movement the armature is advanced in its relation to piston travel. The faster the engine travels the greater the centrifugal force and the greater the distance the block travels. The advancing and returning of the block on its path regulates the advance and retard of the spark. The spring acts against the centrifugal force in controlling the weights and is responsible for the retarding of the spark. The action of the governor is steady at all points and speeds.

With this method of advance the moment of induction is brought about earlier by moving the entire armature and with it the breaker. The cams causing the break are fixed in the correct position to cause the break to occur at the moment when the current in the winding is the strongest. As a consequence of this action the spark, whether at advance or retard, is always at its maximum intensity. This is a distinct advantage.

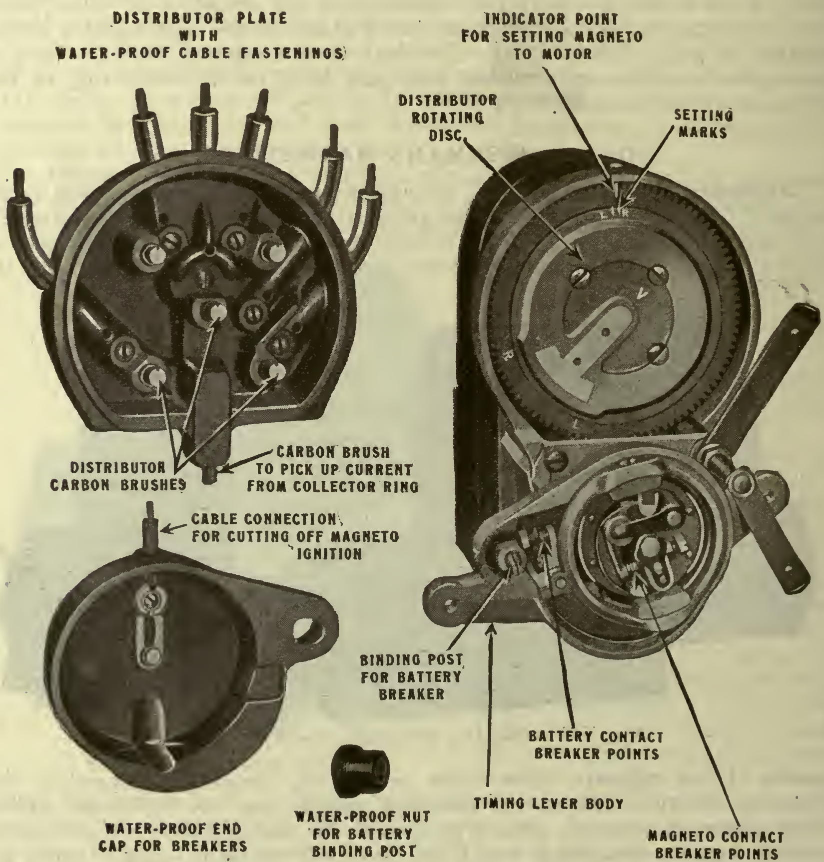


Fig. 488. Disassembled view of Eisemann Type GR4, II Edition.

JOB 146. EISEMANN DUAL IGNITION.

Magneto.—The Type GR4, II Edition, is described and illustrated here. In the main this magneto is the same as the independent type. It differs in two important points. An additional breaker for use in connection with the battery circuit is supplied. The distributor is so modified as to permit of its electrical separation from the magneto armature when distributing the battery

Fig. 489. Eisemann Dual Ignition Coil.

spark. The distributor and breaker construction is shown in Fig. 488. The general care of the GR4 is the same as for the G4 described in Job 144. The magneto may be used in connection with either of the dash coils illustrated.

Coils.—The DC and the DCR coils differ only in the arrangement for starting on the spark or push button starting. The DC coil has a push button

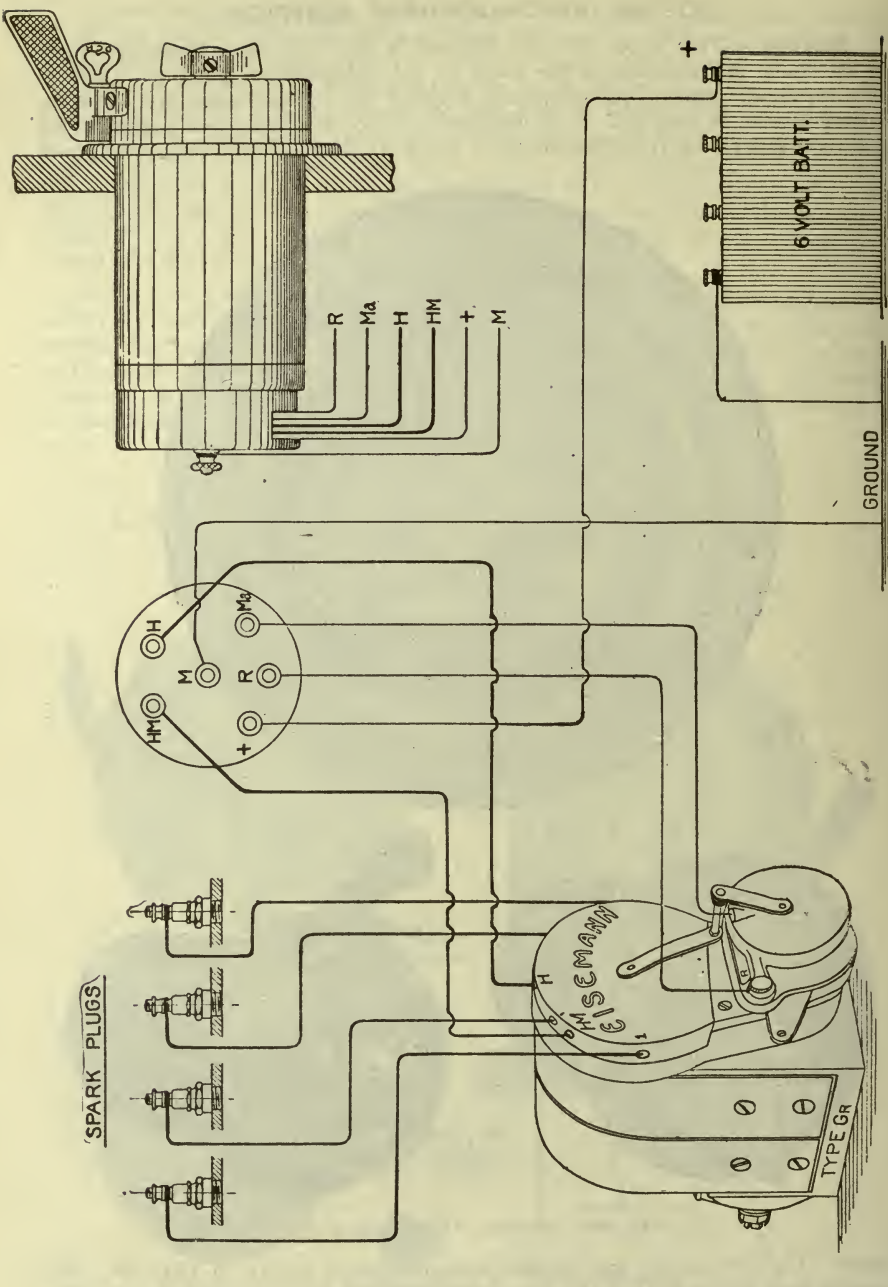


Fig. 490. Wiring Diagram Showing Connections between "GR4" Magneto and either "DC" or "DCR" Coil.

arrangement giving a single spark for starting when the crank shaft and pistons have stopped in such a position that the breaker points for the battery current are open. The DCR has a mechanical ratchet device, illustrated in

Fig. 489, which will give a shower of sparks in the cylinder no matter what the position of the pistons. Rapid twisting back and forth of the starting handle on the front of the coil, causes the toothed ratchet in the center by acting against the fiber roller A to oscillate the lever B, which in turn makes contact alternately at C and D, thus giving a rapid sequence of sparks at the plug then in contact with the distributor brush through its usual circuit.

Wiring.—Fig. 490 gives the full wiring diagram for the Eisemann Dual System. The student can trace out the various circuits, and by referring to the parts shown in Fig. 488, can readily trace out the internal circuits. It has been found advisable to time the battery spark about ten degrees later than the magneto spark as a permanent timing difference. This is an added advantage in starting with the hand crank as the danger from a back fire is materially lessened.

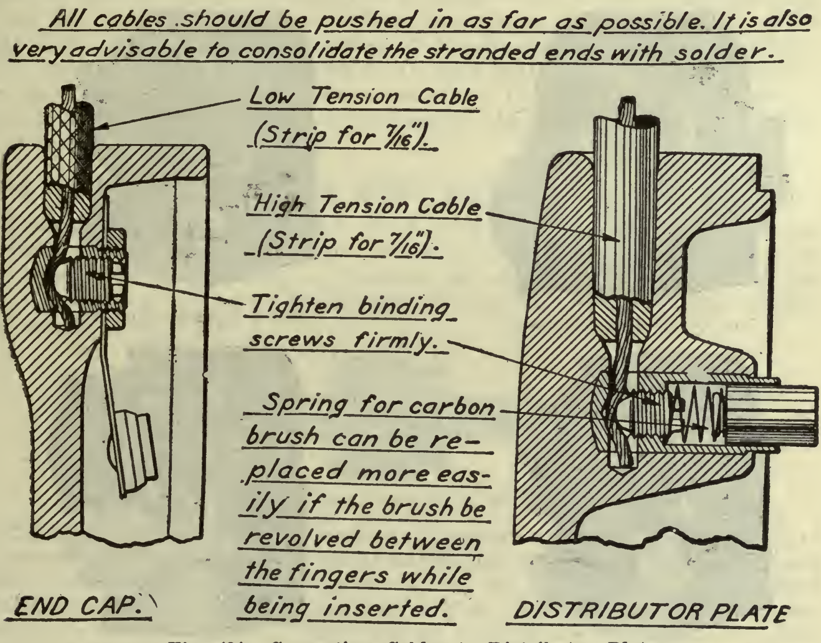


Fig. 491. Connecting Cables to Distributor Plate.

The attaching of the cables to the spark plugs must be made in accordance with the firing order of the motor. The proper fastening of the cables to the distributor and the end cap is of very great importance in order to prevent water or any other electrical conductor making a short circuit between the different connections. Fig. 491 illustrates how these cables should be attached. The connection screw with the round head must not be used for the end cap as the round head will not clear the breaker mechanism. The round head screw belongs in the distributor and should be kept there.

The dual system will operate on either dry cells or storage battery. The latter is recommended by the manufacturers and a six-volt size should be used.

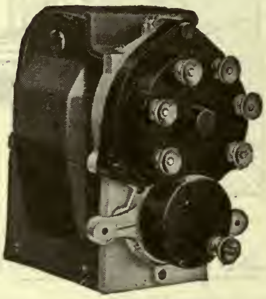
Dual System Troubles.—If the ignition is suspected in case of the motor failing to start, the first step in locating the trouble is to find whether the trouble is in the plugs, coil, or magneto, or any of their respective circuits. The plugs are the most frequent source of trouble and should be examined

first. See that the plug gaps are all equal and from 1/64″ to $\frac{1}{32}$″ apart. Inspect also for fouled, broken, or cracked porcelains.

Contact Points.—Clean these with gasoline until they appear quite white. If pitted, or burned, a platinum point file should be used to carefully true them up. Set the point gap to as near .012″ as is practicable. As these points wear away in time, they should be adjusted by giving the regulating screw a forward turn. First release the locking nut, and after the points are set the lock nut must be secured in position again. If an Eisemann wrench is at hand, use the gauge on its handle to test; otherwise use the feeler gauge to secure the .012″ distance. The eye cannot be trusted to estimate this distance. If all of the platinum is worn off the contacts, new ones will have to be inserted. In this case the contacts are removed until the new ones are in their places when the final adjustment is made with the breaker in position on the magneto.

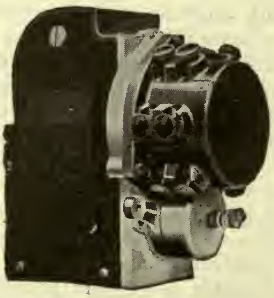
For 2 Cylinder Engines.

For 4 Cylinder Engines.



For 6 Cylinder Engines.

For 8 Cylinder Engines.



For 12 Cylinder Engines.

Impulse Starter Coupling.

Fig. 492. Splitdorf Dixie Magnetos.

Testing the Magneto.—If the motor refuses to start or run on magneto after the points are correct, and the plugs and cables are found correct, the magneto should be tested to see if it is generating a spark. First remove the distributor plate. Next, rest the blade of a screw driver on the gear housing having same in metallic contact. Bring the point of the blade close to the collector ring, about 1/8". Crank the motor. If a spark jumps from the ring to the blade the magneto is generating and the fault is not within it, unless it should be in the brushes or distributor. If these parts on examination are found to be correct, the trouble is elsewhere, possibly in the coil, battery, or even in some other system than the ignition system. The gasoline system will frequently develop faults which are hard to tell from ignition faults.

Operating Engine Without Coil.—To test the coil and magneto in case of trouble, the student will want to remember that it is possible to operate the engine on the dual magneto using it as an independent source of ignition. To do this, first disconnect all wires leading from the magneto to the coil. Next, connect the cables marked H and HM on the distributor plate thus making a direct path from the collector ring to the distributor plate. The instrument then may be used as an independent magneto. To stop the engine a wire is led from the MA connection on the end cap to the dash, and grounded, which acts as a simple switch.

JOB 147. DIXIE MAGNETO. AERO MODELS 448-449 AND 648-649.

Principle of Operation.—The Dixie Magneto made by the Splitdorf Electrical Co. is of the inductor type having the coil windings mounted on the pole shoes above the inductor or rotating element. As will be noted in the illustrations the mounting of the magnets is quite different from that of most high tension instruments.

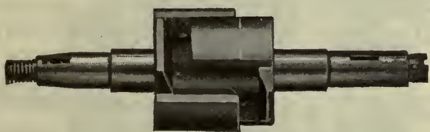


Fig. 493. Rotating Element of the Magneto.

Unidirectional Sparks.—The student will remember that at the beginning of this chapter the direction of the passage of the high tension spark was discussed. From the usual H, or armature type of machine, the design is such that one-half of the sparks go to the plugs through the ground, and return to the instrument through the cables, while the other half go through the cables to the center electrode of the plug, and return to the magneto through the engine frame. The Dixie is so arranged as to have all of the sparks travel in one direction.

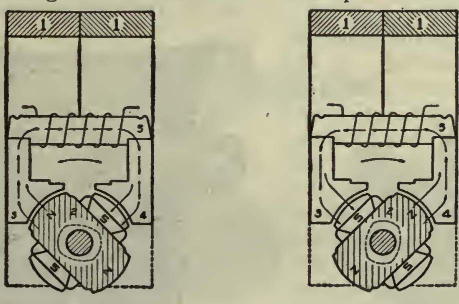


Fig 494A. Fig. 494B.

Magnetic Flux. —

Rotating Element.—The rotating element, or inductor, is made up of a shaft and core having four wings or poles cast integral. This is shown in Fig. 493.

Magnetic Flux.—In Fig. 494A the magnetic flux flows in one direction through core 5. When wing N is opposite 3, flux flows to 3 and through 5 to 4, back to wing S of opposite polarity. Until the wing N has passed the leaving pole piece 3, the action of the cam holds the breaker contacts apart, thereby preventing the induction of current within the primary circuit about the core 5. This leaves the core free from magnetic interference and prepares it for a powerful magnetic and electrical action when the polarity of the field structure and core is reversed upon further rotation of the rotor.

Fig. 494B shows the magnetic flux flowing in the reverse direction through core 5. Wing N has moved over to 4 and the directon of flow of flux has been reversed now flowing from 4 through 5 to 3. When wing S passes the leaving pole, piece 3, the action of the cam separates the platinum contact of the breaker thus interrupting the primary current which has been built up in the primary winding of the core 5. The induction of the secondary current occurs in the secondary winding of the core 5 as the points separate, breaking the primary current and causing the collapse of the lines of force about the core. The reversal of polarity of the core assures its complete demagnetization, and the consequent lively action of the instrument in producing the high tension spark.

Magneto Care.—The proper space between the interrupter points is .020″. Be certain the gauge used is the proper size. The platinum points should be kept free of all dirt, dust and oil. Should they become burned or pitted from constant service, the platinum point file may be used to true them up. The utmost care must be used to have them making contact over the entire surface.

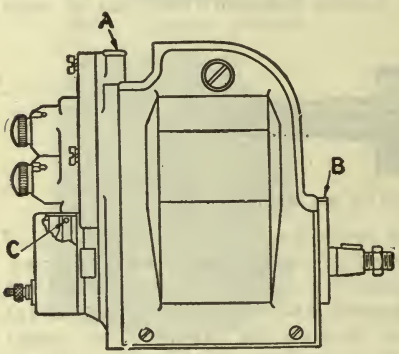


Fig. 495. Points for Oiling.

The distributor block should be removed occasionally and inspected for an accumulation of carbon dust. Clean with a cloth moistened with gasoline. Dry with a clean, dry cloth.

Do not pull out on the carbon brush to increase the tension on the spring.

Oiling.—Refer to Fig. 495. For passenger cars the magneto should be oiled at A with four drops of very light oil every 1000 miles of operation; at B with 2 drops every 1000 miles, and at C one drop of light oil should be applied to the bearing of the breaker bar with a tooth pick every 200 hours of operation. Fig. 496 illustrates the breaker base and the hole for oiling the breaker bar bearing. Every possible precaution should be taken to prevent the oil from getting on the platinum points. The magneto will not operate satisfactorily if this happens. Flashing at the points and misfiring of the engine will be evident.

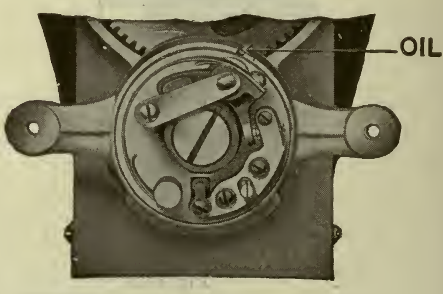


Fig. 496. Oiling Diagram.

When the Dixie is used as the ignition source on trucks and tractors the points A and B will require oiling at more frequent intervals. Point C the same.

Timing the Magneto to the Engine.—First bring piston No. 1 to the top of the compression stroke. Next, retard the spark timing lever fully. While rotating the magneto in the direction it is driven, the breaker points should be observed. Continue turning the rotor armature until the points are just about separating. Maintaining the magneto in this position, the coupling to the engine may be effected. Next secure the instrument to the engine.

Without changing the position of the parts, the distributor cover is removed to determine which terminal of the distributor block is in contact with the finger of the disk. Lead the plug wire from this terminal to cylinder No. 1. Connect the remaining plug wires in turn according to the proper sequence of firing of the cylinders.

JOB 148. DIXIE MAGNETO. MODELS 46, 462 AND 246.

The Dixie Magneto is of the high tension inductor type. The rotating member or inductor consists of two pieces of magnetic material separated by a non-magnetic centerpiece. Since the magnets are mounted just outside the

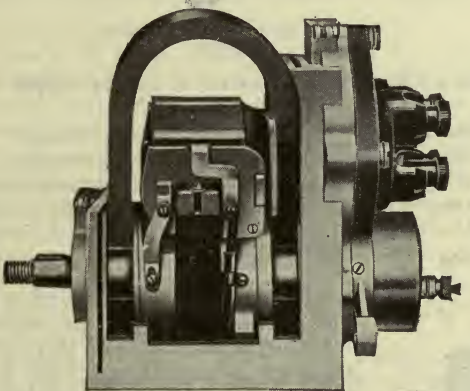


Fig. 497. Magneto with Cover and One Magnet Withdrawn.

magnetic parts of the rotor, these are really rotating pole pieces. The polarity of the pole pieces does not change as the rotor is turning. Change of polarity takes place only in the laminated field pieces and core of the winding. There is no winding on any of the rotating parts. A core carrying both primary and

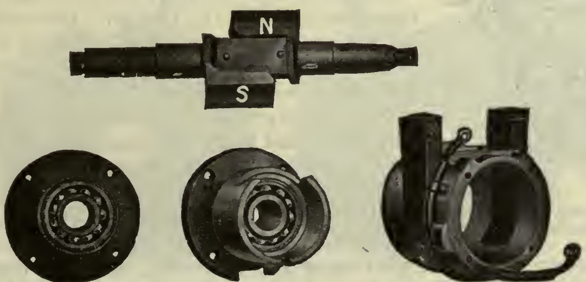


Fig. 498. Rotating Poles, Bearing Holders and Field Structure.

high tension winding is housed under the arch of the magnets above the rotor. The core of this winding is fastened to the field pieces. The field pieces and winding are mounted together and made to turn back and forth to give the advance and retard of the spark. The breaker is stationary. No sliprings or brushes are necessary since there are no rotating windings.

The winding and the condenser can be removed from the magneto without removing the instrument from the engine. The condenser is readily accessible and placed in a position where it is connected directly across the primary winding breaker points.

Fig. 499. Dixie Magneto Switch.

Magneto Care.—The directions given in Job 147 apply to these models as well.

Dixie Magneto Switch.—The Dixie Magneto breaker cover is provided with a terminal for connecting the primary to the grounding switch. The wire leading to the switch from the magneto must be attached to the insulated terminal. The other terminal is grounded by running a wire from it to the car frame.

JOB 149. THE SPLITDORF IMPULSE STARTER.

The action of the impulse starter may be compared to a cranking speed of about 500 R. P. M. This is possible since the impulse starter is so constructed that at very slow cranking speeds the armature is caught and held, until at the proper point on the compression stroke the spring, which has been put under tension, is released, and the armature snapped forward at a high rotative speed, until it again resumes its natural position with reference to the engine. The action is as follows:

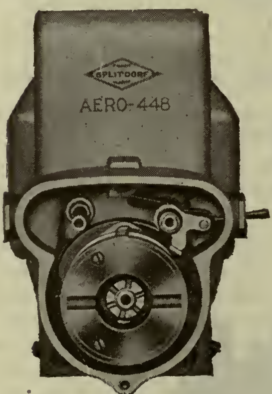


Fig. 500. Cover Removed to Show Impulse Starter.

Referring to Fig. 501. The member A is keyed to the drive shaft of the magneto and contains the notches C and D. The pawl E carries projections F and G, and is movable about its axis H. The cam member J has two cams K and L and also carries the trip lever M.

When starting the engine, the parts rotate at low speed and the centrifugal force is not sufficient to throw the trip lever M out from the center, hence the point N of the lever engages with the projection G of the pawl and causes projection F to engage with the notches C or D.

The member A is now prevented from turning, but cam member J continues to turn and compresses the coil spring U inside of A until cam K or L

releases the projection F. The coil spring then rotates the member A at high speed, and as it is keyed to the magneto shaft a strong spark is produced at the plug. This spark always occurs several degrees past top dead center, regardless of the position of the spark lever, advanced or retarded.

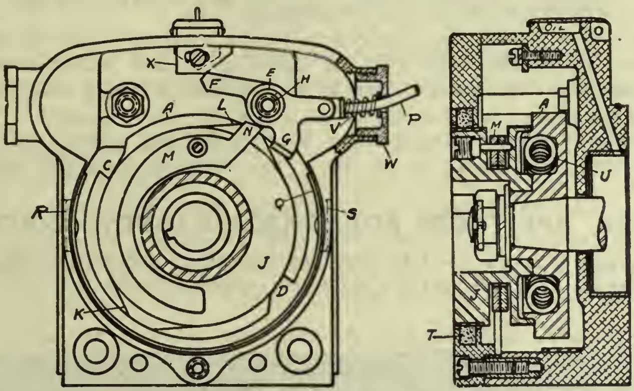


Fig. 501. Details of Construction and Operation of Impulse Starter.

The pawl projection F continues to engage in notches C or D until the speed reaches 150 to 200 R. P. M., at which the blow from the cam is sufficient to throw the pawl E against the stop X into an inoperative position.

At this speed the trip lever M is thrown out by centrifugal force so that it no longer engages with pawl projection G as the trip lever does not engage above 120 R. P. M. This permits of the engine being throttled down to idling speed without the trip lever coming into action.

The lever P on the side of the housing is provided in order that the pawl E can be engaged by hand if necessary. The cover plate is provided with a large felt gasket to exclude dust and other foreign substances. See that this is always maintained in good condition.

The stop X is adjustable. Moving it to the right permits the starter mechanism to come in or function at lower speeds.

Impulse Starter Care.—The spring is packed in grease. If it is necessary at any time to renew the supply, use a grade which will not harden in cold weather. The starter mechanism may be cleaned by removing one of the screw plugs and injecting kerosene with an oil gun.

To replace the spring first insert a nail or pin through the lateral hole, as

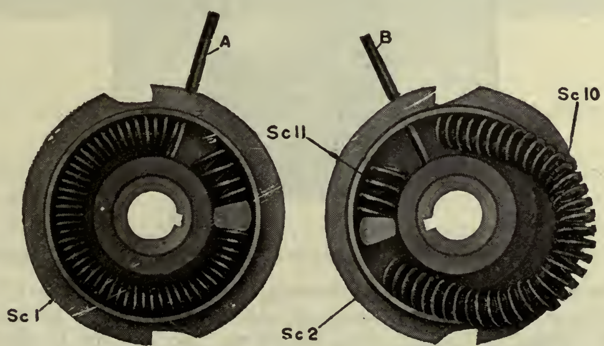


Fig. 502. Method of applying Impulse Starter Spring.

shown in the illustration. Next press the ends of the spring into the recess. The middle section of the spring may then be forced to its position within the recess. This method of assembling leaves a suitable space between the two spring ends for assembling the cam member J, with its top member in this space, after which the pin or nail is removed.

The member A may be removed from the magneto shaft by inserting a screw driver or similar tool into the opening at each side of the housing. These openings are normally closed by the buttons R and S and held in place by the buttons Q.

The impulse starter should never be thrown into engagement while the engine is running. To do so is likely to result in damaged parts of the mechanism.

JOB 149A. SPLITDORF ADJUSTABLE MAGNETO COUPLING.

This coupling is designed to give any degree of magneto-to-engine timing that is desired. Figs. 503 and 504 show the coupling in detail and in assembled section.

When the cone is drawn into the collar by means of the large nut on its

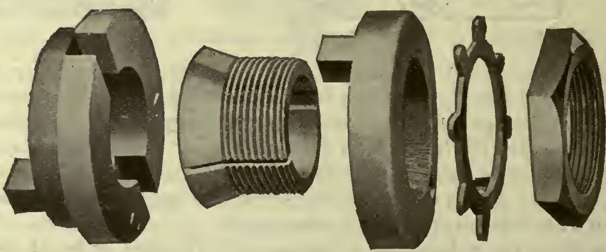


Fig. 503. Details of Splitdorf Adjustable Magneto Coupling.

threaded outside, the cone clamps onto the shaft, the collar setting tightly on the cone, making a compact whole which, through a tongue, drives the floating member.

By loosening the nut and the collar on the cone the collar is made free

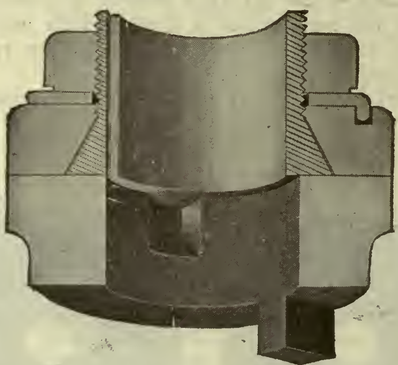


Fig. 504. Cross Section of Splitdorf Adjustable Magneto Coupling.

to turn. Since it alone carries the driving tongue the relation of the magneto time to the drive shaft is easily attained. When the desired timing position is attained, the collar is locked onto the cone. Be certain to have the lock washer in position under the locking nut.

CHAPTER 14

STARTING MOTORS AND GENERATORS

In Chapter 11 dealing with the fundamentals of electricity and magnetism, the general characteristics of motors and generators were discussed. There are two distinct types of equipment in popular favor. In one case the starting motor and generator are combined in one instrument giving the Single Unit System. In the other case the starting motor is built separate and apart from the instrument used for generating current and this method of construction and design is known as the Two Unit System. In actual service there seems to be little choice between the two types. Most excellent

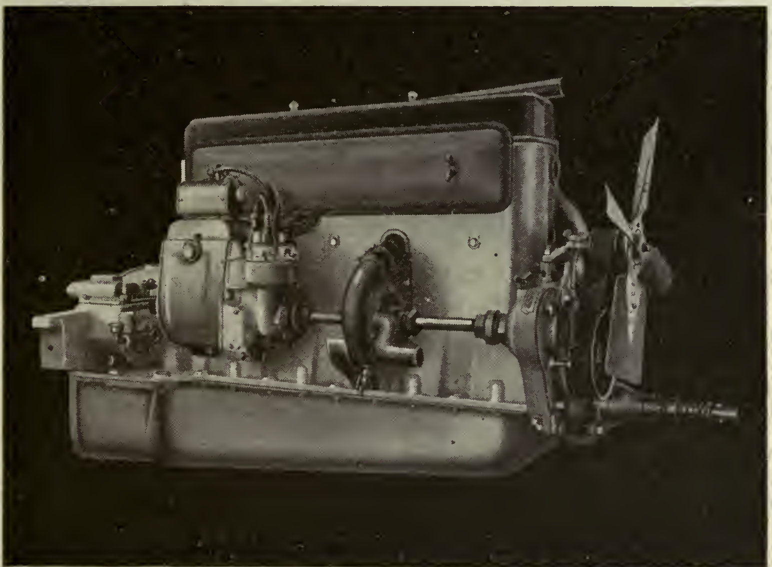


Fig. 505. Buick Delco Motor Generator.

instruments of each type are manufactured by a number of companies.

Division of Duties.—Whether the type be the single or double unit, the division of duties of the instruments is the same. The storage battery is common to each instrument. In the work of cranking the motor, the battery furnishes a heavy surge of current (150 to 300 amperes) to do the work of turning the armature over as it in turn turns over the engine through the medium of gears or chains. The parts in circuit when the engine is being cranked are

the battery, the starting switch, the brushes and starting motor armature, and field windings.

Once the engine has started to operate on its own power, the operator opens the starting switch thus opening the starting circuit, and stopping the drain on the battery. As the engine speed increases,

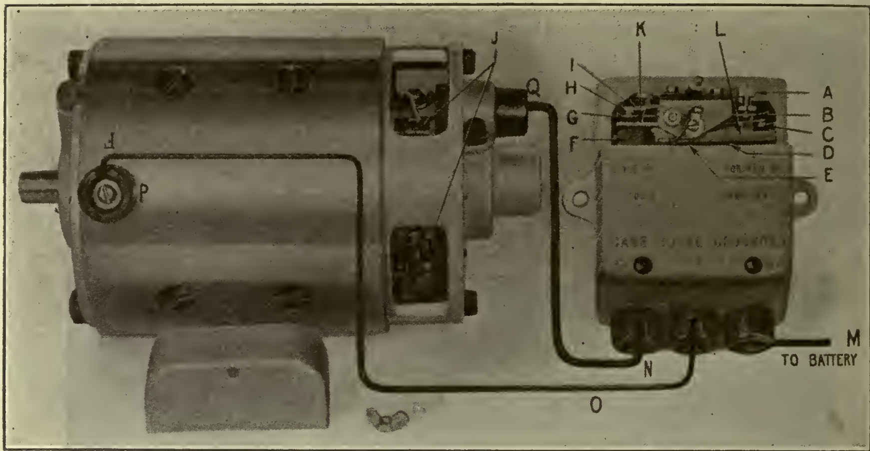


Fig. 506. Pierce Arrow Generator with Voltage Regulator.

the generator being driven by the engine is brought to a point at which the voltage within the internal circuit of the generator is higher than the E. M. F. (Electro Motive Force) of the battery. At this point the battery to generator circuit is closed and current starts flowing to the battery from the generator. In this way the current drawn from the battery for cranking the engine as well as that used for lighting and ignition is replaced. The generating circuit includes the generator, the battery, the ammeter, and the cut-out relay, as well as the fuses in some cases. The cut-out relay or automatic cut-out serves the purpose of cutting the battery into and out of circuit with the generator in an automatic manner. This prevents the battery discharging through the generator when the generator is operated at speeds too low to overcome the battery voltage. This is explained more fully at a later point.

The division of duties as outlined for the generator and starting motor applies equally whether the system is the single or the two unit system. In a general way also the method of control of the generator output applies to either type.

Regulating Generator Output.—Owing to the fact that there are unusual conditions and obstacles confronting the engineers designing generators for automotive equipment, it is perhaps well for the student and mechanic to have an understanding of these conditions.

The speed of the engine is variable. The speed of the generator, depending as it does on the engine speed, is also variable. The generation of the current within the dynamo, which is what the instrument in reality is, is always dependent on the following factors, three in number.

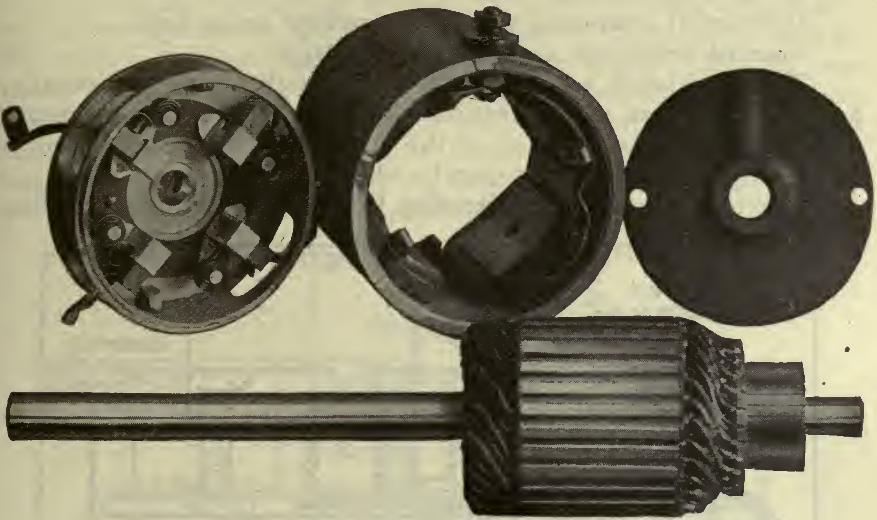


Fig. 507. Westinghouse Starting Motor.

The first of these is the magnetic field or magnetic flux.

The second is the conductors which are made to cut this magnetic flux.

The third is the power causing the conductors to rotate in the field and cut the flux, in this case the engine.

In order to have the instrument generate electrical current, all three of these factors must be available and working together in proper relationship. The voltage which is then generated is always proportional to the product of these three factors. That is, the strength of the magnetic field with the number of armature conductors, with the speed of armature rotation, governs the voltage or pressure generated.

To the student it is then apparent that changing any one of these three factors will affect the output. Increasing either of the three factors increases the output, while the decrease of any of the three will decrease the output. On the other hand, if while one factor is decreased one of the two remaining factors is increased; the resulting voltage may be maintained at the desired point. Counterbalancing one factor which is variable by making another variable is the principle of practically all regulating systems. The speed of the armature as indicated above is the factor which it has been found impracti-

cal to maintain at a fixed figure. The forced variation within it of approximately 4,000 R. P. M. is counteracted by some device which will control the density of the magnetic flux. This modification may be effected in several ways, the most usual of which are the following:

Third brush control.

Differential compound wound, or bucking series field.

Inserted resistance, or vibrating regulator.

The third brush control is the most popular. Very frequently, however, it is used in conjunction with some other means of output control. These auxiliary aids to the third brush will be explained in the description of the equipment in which they are used.

Inserted Resistance or Vibrating Relay Controller.—In this case

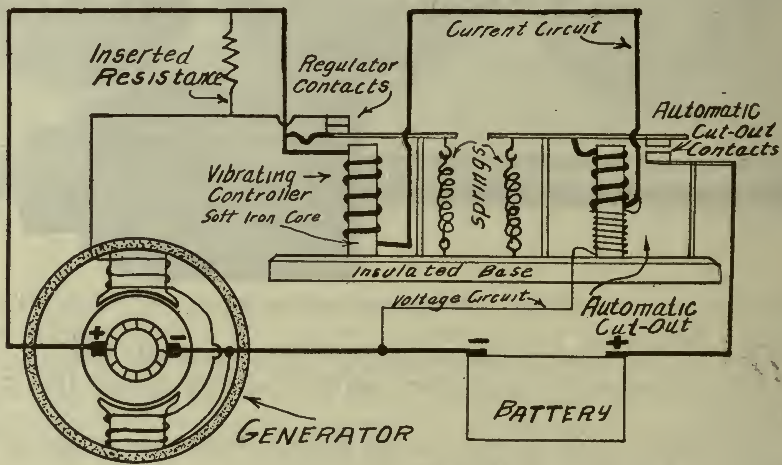


Fig. 508. Inserted Resistance Control. Current Circuit used on Coil. Automatic Cut-out in Circuit.

the output of the generator is controlled by the magnetic action of the vibrating controller. The device consists of a soft iron core with either a voltage or a current coil wound on it. In some cases it is supplied with both. In the latter case the automatic cut-out is incorporated with the controller relay. The student must not confuse these two instruments. A casual glance would lead to the conclusion that they were the same as each is equipped with contact points held in position by a spring. In the cut-out the points are normally open, allowing current to flow only when they are drawn together by the magnetic action of the core. Just the reverse is true in the case of the relay controller. The points are normally held together. When the current flowing through them becomes equal to the desired generator output for battery charging or lighting use, the action of the controller is so arranged that the strength of the spring holding the

contacts together is overcome by the magnetic action of the core and winding, thus drawing the points apart.

As the points separate, a bit of resistance wire is inserted into the circuit which regulates the strength of the field. The resistance cuts down on the amount of current permitted to flow to the field circuit. As the strength of the field is thus decreased, the amount of current generated within the armature is necessarily likewise decreased. As this output is decreased, the magnetic pull of the controller core on the soft iron part carrying the movable contact point is decreased to such a point that the pull on the spring is greater than the magnetic pull and the points return to normal position. The resistance which really controls the output is thus cut in and cut out many times a second. It is usually brought into action at from

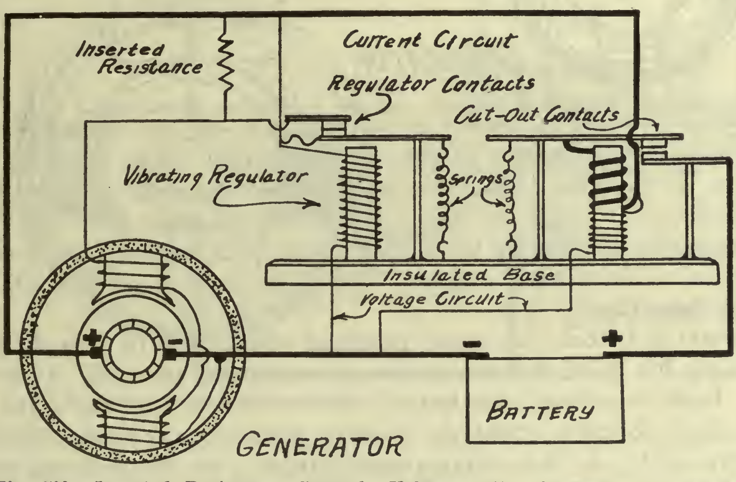


Fig. 509. Inserted Resistance Control. Voltage coil only used on regulator coil. Automatic Cut-out in Circuit.

twelve to eighteen miles per hour. The device may be used either in connection with the voltage or the amperage of the generator. If the current or amperage is depended on, the controller core is wound with wire heavy enough to carry the entire output of the generator. If voltage or pressure is depended on for regulation, the wire may be very light and the ends of it connected across the generator brushes in a plain shunt.

The student does not want to lose sight of the fact that the output of the generator is actually controlled by the inserted resistance and that the relay is made to insert and withdraw this resistance automatically, and in such degree that the amount of current flowing to the battery and lighting circuit is maintained at a uniform value no matter what the operating speed of the engine. As the field builds up, the output increases. Armature speed, one of the three controll-

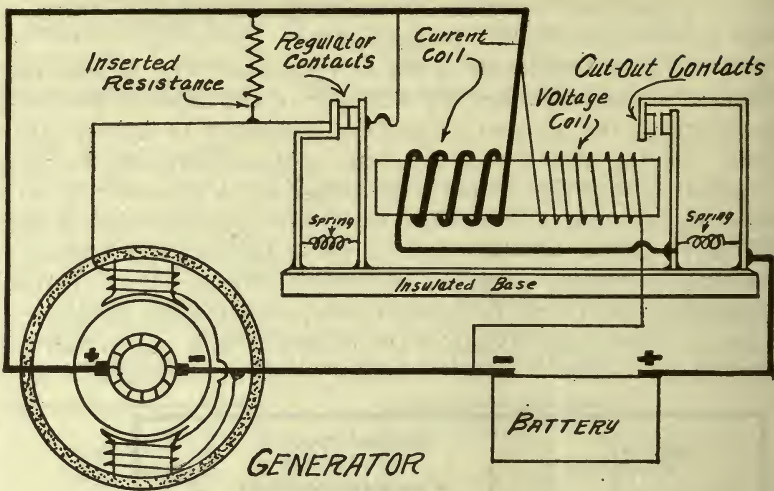


Fig. 510. Inserted Resistance Control. Cut-out and Regulator combined with both current and voltage coils assisting in the operation of each part of instrument.

ing factors, is responsible, as part of the current taken off from the armature through the brushes is shunted into the field to build that. Consequently, to offset the speed factor the magnetic field strength is decreased by preventing the return to the field, winding the normal proportion of armature output. The insertion of the resistance accomplishes this.

As stated before, the usual practical application of this method is through the combination of the automatic cut-out and vibrating relay. Both windings, the heavy current circuit and the light or fine winding shunted across the brushes, thus influence the action of the instrument. As the voltage starts building up when the generator is driven by the engine, the cut-out points are closed. When closed the current starts flowing through the current winding to the battery. This adds to the magnetic pull affecting the closing of the cut-out points and helps to hold them securely together. Both coils acting together, since they are wound on the core in the same direction, affect the action of the vibrating points. The spring tension controlling the separation of these points is regulated to increase or decrease the output of the machine. Increasing the tension on the spring means that more current must flow at a higher voltage before the contacts open and the resistance is inserted. Decreasing the tension on the spring means that there is less voltage and less current flow required to separate the points and insert the resistance. As a consequence the output is increased or decreased at the desire of the mechanic.

Differential Compound Wound or Bucking Series Field.—It is presumed that the student is familiar with the terms shunt and

series as applied to the winding of generators and motors. The action of the type of regulation depending on the bucking series field is easily understood if it is remembered that winding an electromagnet with many turns of wire will, when current is sent through the wire, make one end of the electromagnet north and the other end a south pole. Reversing the direction of the winding will reverse the polarity. That is the pole formerly north is then a south pole, and vice versa. If, on the other hand, a number of turns of wire are wound on in one direction and then the direction of winding is reversed and a like number of turns put on in the opposite direction, it is evident that there will be a bucking effect between the two coils

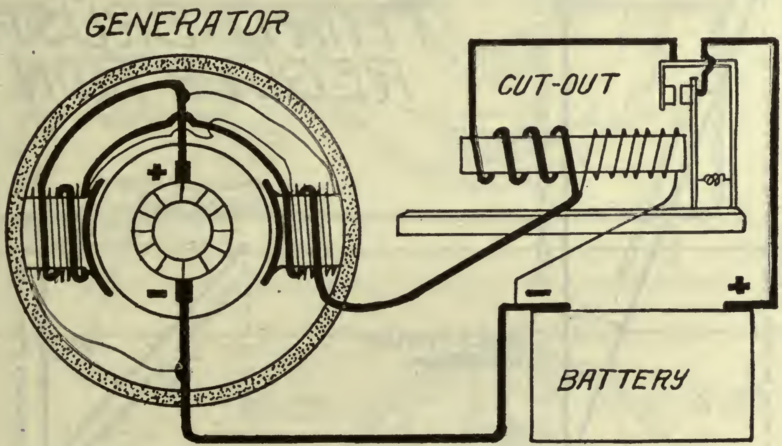


Fig. 511. Bucking Series Field with Automatic Cut-out in Circuit.

as the current is run through them. One coil would attempt to make a north pole out of a certain end of the core, while the other coil would attempt to make the same end into a south pole. If the coils were just equal there would be a complete neutralization of the magnetic effect and there would be no decided polarity evident. The magnetic field or flux would be destroyed.

In the bucking series field regulation this is the basis of the control. Part of the output of the armature is run through the field to build it up. This is called a shunt field. If all the current passing through the armature winding were passed through the field that would be series winding. In this case the shunt winding which is the longest is wound in one direction about the pole shoes to form the electromagnet and set up the magnetic field. The charging current also taken from the armature brushes is run about the pole shoes in the opposite direction in its circuit, and before it is carried through the automatic cut-out and ammeter to the battery.

Consequently, as the output grows, more and more current will pass around the pole shoes in the opposite direction to that building

up the field. This current bucks or neutralizes the magnetic flux or field by attempting to build up a field of reversed polarity, with the result that the stronger field is bucked or partially neutralized. Since the magnetic field is one of the determining factors of all generators it will be seen that the neutralization of part of the field will cause a falling off of the output. The increased output, due to higher armature speeds, is used to neutralize the field and reduce itself. As in the case of the vibrating controller the increase of armature speed, which is one of the three factors, is offset by a decrease of the mag-

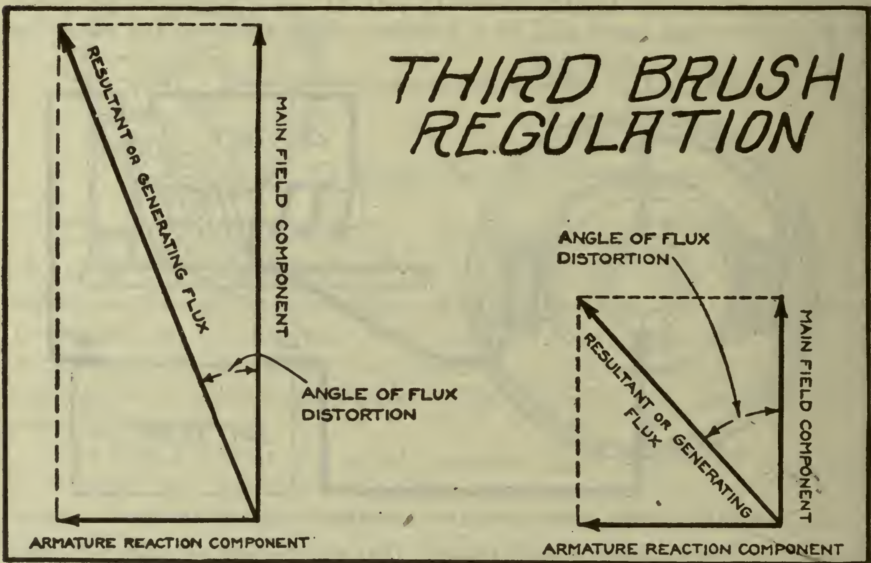


Fig. 512. Parallelograms illustrating degree of flux deflection due to the armature reaction.

netic field factor. The same result is accomplished by different means. This method entails no moving parts. There is no method of readily increasing or decreasing the output. If the circuit used to charge the battery and light the lamps should fail for any reason no current would be traveling in the reverse direction to buck down the shunt field circuit. This would permit the voltage to build up and up until, if the car were operated at considerable speed the field and voltage coil on the cut-out would most certainly be burned and damaged. Consequently great care must be used to see that all terminals are tight and the wiring complete.

Third Brush Control.—In this system which is used to a greater extent than any other the governing factor is the armature reaction. When the electric current flows through the coils of the armature as it is generated it magnetizes the iron core of the armature. This

magnetism is termed cross magnetism and affects the main field magnetic flux.

With the main magnetic field established at full strength by the exciting current flowing through the field coils, the lines of force will

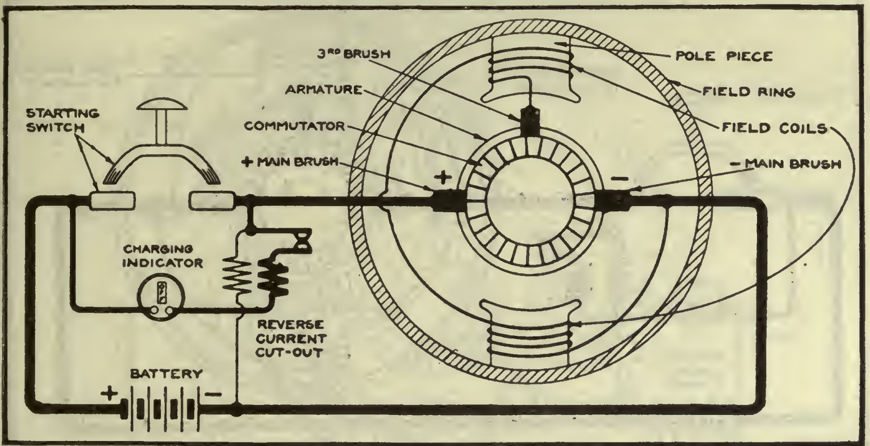


Fig. 513. Starter Generator not in operation. Third Bush Control.

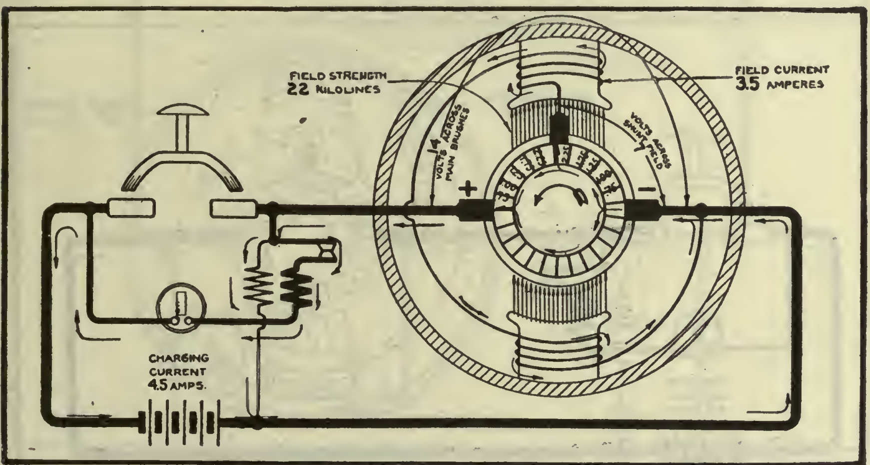


Fig. 514. Starter Generator running at 1200 R. P. M. Third Brush Control.

leave the north pole, pass across the first air gap to the armature, through the armature to the second air gap, and across it to the south pole. If the armature is not in motion and no current is flowing through its coils to set up the cross magnetization, the lines of force pass across from the north to the south pole in a straight path. However, with cross magnetization present, the armature flux thus

produced creates a secondary field having a marked influence on the main field.

This cross magnetization is at right angles to the lines of force flowing in the main field. It is this fact that is relied on to control

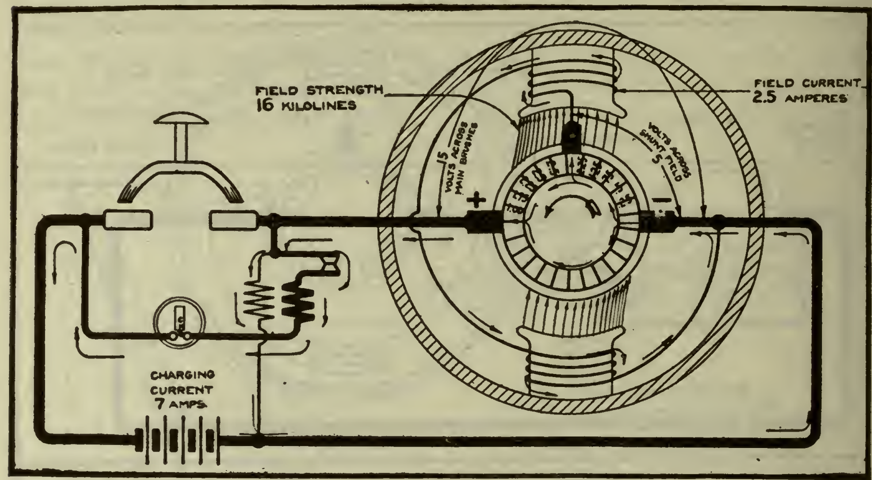


Fig. 515. Starter Generator running at 2200 R. P. M. Third Brush Control.

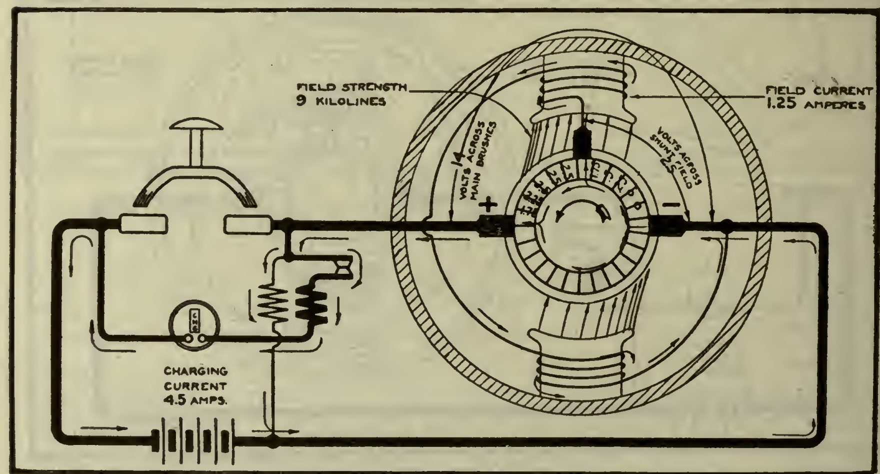


Fig. 516. Starter Generator running at 5000 R. P. M. Third Brush Control.

the field flux and consequently the generator output. It is a well known fact that two forces coming together at an angle will result in the combined force following a line which is that of neither of the first two forces. If the two forces are equal the angle of distortion will be such as to bring the line of the new force half way between

the two originals. However. if there is one weaker than the other the line of distortion will form a smaller angle with the line of the main force than if they were equal. Refer to Fig. 512.

In the application of this principle to the generator the main lines

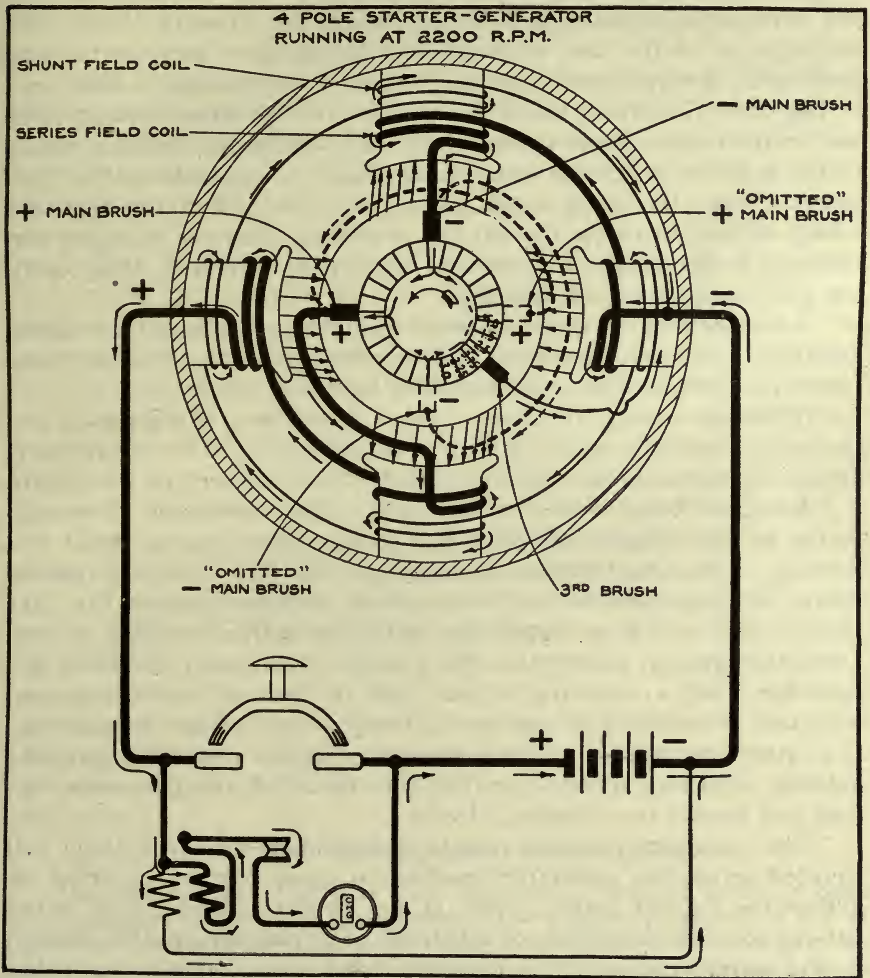


Fig. 517. Wiring Diagram showing Dodge Northeast Starter Generator operating at average speed.

of force are those passing from the north to the south pole shoes. The distorting force is the armature flux. When the generator is idle or just starting to generate this force is negligible. However, as the output increases, the force tending to distort the field flux also increases. As this force grows stronger and stronger, the main flux

is distorted more and more. When the main field flux is distorted fewer lines of force are cut by the armature conductors when in such position that the current can be taken off by the brushes. This results in a decrease of the output with the result that the cross magnetization and main flux distortion are also less. Again the output is made to regulate itself by decreasing the strength of the field, the same as in the case of the vibrating regulator and the bucking field types of regulation. The part the third brush plays is illustrated in Fig. 517. The third brush is at the point of greatest voltage value with reference to the armature coils. The armature reaction results in the greatest armature value being thrust to one side of the third brush. Since the third brush takes the current from the armature which is used to excite the field, it is evident that not as much current will be taken off by it when the distortion is greatest, thus resulting in a decrease of the field flux.

The speed factor again attempts to build up the armature output. Because of armature reaction and the third brush location the speed factor is offset by the weakened field factor.

There are many variations of these three types of regulation, but the main principles involved have been explained. The variations in certain instruments are described under their respective job sheets.

Cut-Out Relay.—The cut-out relay is an automatic switch inserted in the charging circuit. The construction may be noted in a number of the illustrations, for example Fig. 511. Not all systems utilize the automatic cut-out. A number of Delco systems have had the cut-out switch in connection with the ignition switch so that when the ignition takes place the generator will start motoring and continue doing so, drawing current from the battery until the generator speed is sufficient to produce an output and voltage greater than the battery voltage, at which point the generator starts charging the battery. Turning off the ignition also turns off the generator current and breaks the charging circuit.

The automatic cut-out switch is dependent on the voltage coil shunted across the generator brushes, to make contact, or bring together the cut-out points. This is due to the magnetic pull of the cut-out core which is made of soft iron. The magnetic pull is resisted by the spring tension. The strength of the spring must be such that it will hold the points open until the generator voltage is slightly more than that of the battery. Under this condition, when the points are closed, the current will flow immediately to the battery to charge it and no discharge is possible. Referring to Fig. 511 the student will note that the current coil is wound on the core in the same direction as the voltage coil. Accordingly when the contact points close the magnetic pull of the iron core is increased and the switch is made all the more positive in action.

The student must not confuse the vibrating control points with the cut-out points. The latter remain closed once the generator speed assures a sufficient voltage until the speed of the generator drops too low when they are automatically opened. The regulator points, on the other hand, vibrate rapidly, alternately inserting and cutting out the inserted resistance which is used to regulate the magnetic field, and consequently the generator output.

Since the cut-out is closed automatically, it must likewise be designed to open automatically. When the voltage builds up to a certain point the contacts close and current flows as stated previously until the generator speed falls below the point where the voltage is below that of the battery. When this happens the current starts flowing not from the generator, but from the battery to the generator. This reversal of current in the charging circuit attempts to reverse the polarity of the cut-out core and in so doing neutralizes the current flowing through the voltage coil which has no connection to the battery. In this manner the pull of the iron core is neutralized and the spring pulling on the contact causes it to be opened immediately. If the engine is being stopped the points remain open. However, if the engine has slowed only momentarily, the points will close immediately the car and engine speed again passes the predetermined point, about seven to ten miles per hour.

The entire purpose is to automatically switch on and off the charging circuit in such manner that no attention need be given to the act by the operator of the machine. Occasionally the cut-out points will stick. If this happens, the battery will be discharged back through the generator. Where the system is equipped with an ammeter this fact may be detected by its action. The hand would stand at possibly ten to twenty amperes discharge with the lights and ignition off. Points will stick because they are burned by an excessive charge, or because of failure of the spring or other mechanical parts.

JOB 150. WAGNER STARTING MOTOR.

As used on the Studebaker cars the Wagner starting motor is rather representative of the entire Wagner line. The machine illustrated in Fig. 518 utilizes reduction gears to cut down the speed and increase the cranking power. A further reduction of speed and increase of power is secured through the use of a small sprocket on the starter gear shaft and a larger one on the crankshaft of the engine. This latter is mounted on the forward end of the crankshaft and includes an over-running clutch in the hub on which it is mounted as part of the starting equipment. This clutch allows the engine to drive faster than the starting motor once it begins to operate under its own power. The Wagner line includes the popular bendix drive as well as the reduction gear chain and sprocket types mentioned above. Fig. 520 illustrates a bendix drive gear reduction combination, built by the same company.

The single unit method of construction is employed in all Wagner equipment. A particular item of interest is the size of the starting motors. These

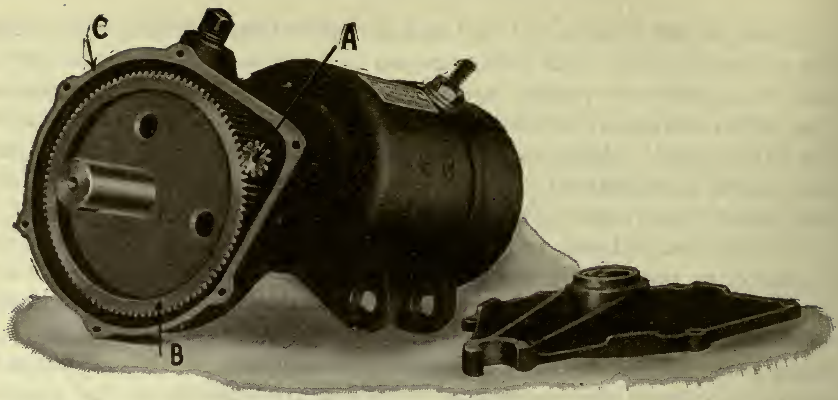


Fig. 518. Wagner Starting Motor.

are always small and light. Through proper design and gear reduction the very small instrument has proven equal to the task of readily spinning heavy six cylinder engines even under adverse starting conditions.

Starting Switch.—From the car wiring diagram, Fig. 557, it may be noted

Fig. 519. Light and powerful starting motor, driving through chain and over-running clutch (Studebaker).

that a large cable from the negative side of the battery is fastened to one side of the starter switch. This switch, shown dismantled in Fig. 521, is of the plunger type. It is so arranged that when the plunger is depressed it makes contact with the two copper contact segments located in the base of the switch

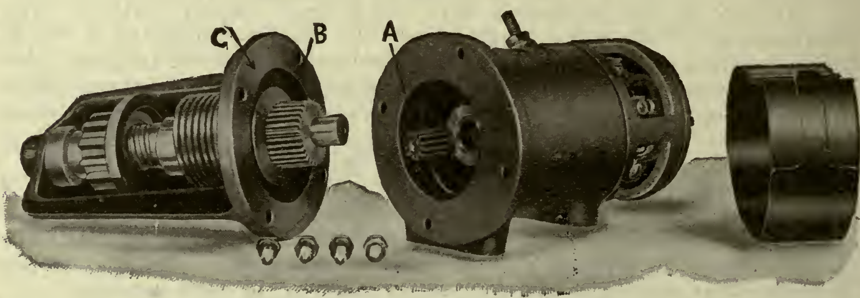


Fig. 520. Wagner Starting Motor with Bendix Drive.

connecting them, thus providing a closed circuit from the battery to the starting motor.

In case of any trouble with the switch it should be disassembled and cleaned. If the springs on the plunger have become bent out of shape they should be repaired by springing until they will make firm contact. Be very certain not to harm or displace the insulating materials, otherwise short circuits will develop and cause battery and starter trouble.

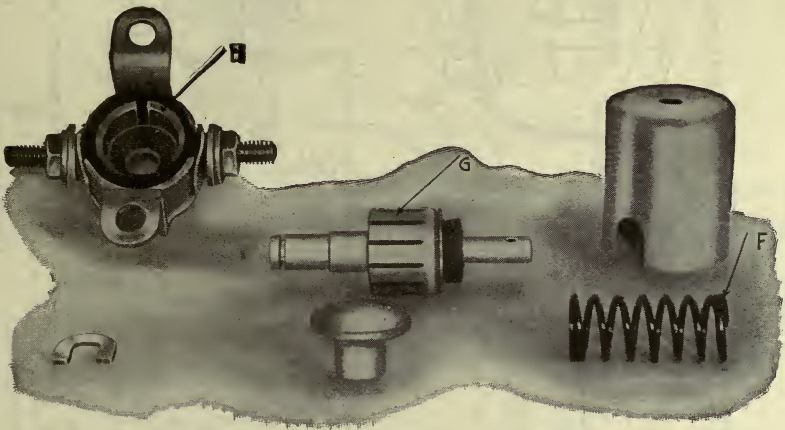


Fig. 521. Wagner Starting Switch.

JOB 151. BUICK DELCO MOTOR GENERATOR.

Motor Generator Operation.—The motor generator performs the three following operations:

1. **Motoring the Generator.**—This operation is necessary in order that the starting gears may be brought in mesh with the small gear on the armature shaft and with the teeth in the fly wheel. This motoring of the generator takes place whenever the lever on the left-hand side of the ignition switch is turned to position marked "On," thus completing the circuit from the battery to the generator windings. This discharge of current is through the shunt field windings and the generator windings on the armature. The motoring speed of the generator is slow.

2. **Cranking Operation.**—The cranking operation is performed when the starting gears are brought fully in mesh and the motor brush makes contact with the commutator. The brush thus brought into contact with the commutator after the gears are properly meshed serves the same purpose as closing a switch. A heavy current flows from the battery to the starter windings of the machine. It is very essential that all parts such as brushes, terminals, etc., make good electrical contact.

3. **Generating Operation.**—After the engine has been cranked and starts to operate under its own power, the starting pedal is returned to its normal position by a spring action. This demeshes the starting gears, at the same time raising the starting motor brush from the starting motor commutator, and lowers the generator brush onto the generator commutator from which it is always lifted while cranking the engine. At very low speeds the voltage generated is not sufficient to overcome the voltage of the storage battery, and a small amount of current may be discharged from the battery through the

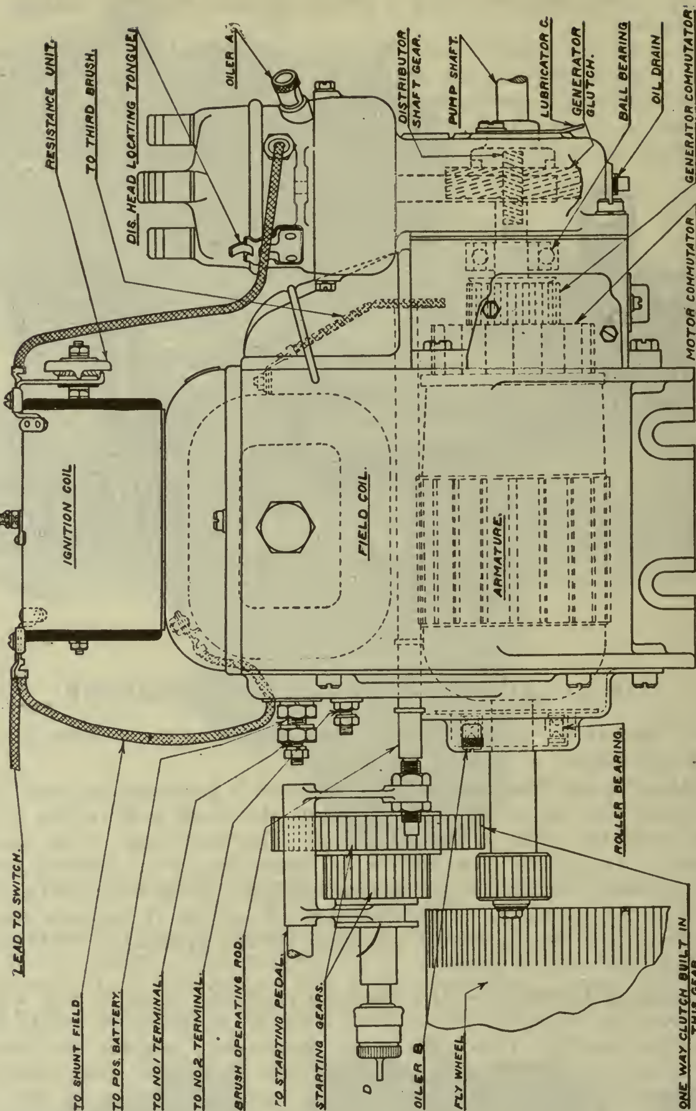


Fig. 522. Buick Delco Motor Generator with Ignition Units.

generator winding. At all normal engine speeds the voltage of the generator is sufficient to overcome that of the battery and the current flows through the battery and recharges it.

The ammeter on the dash registers the rate at which the storage battery is discharging, or the rate at which the generator is charging the battery.

Current Control and Output Regulation.—The current control is effected by the third brush system of regulation. To regulate the output the brush must be moved to the right or left as indicated in Job 156.

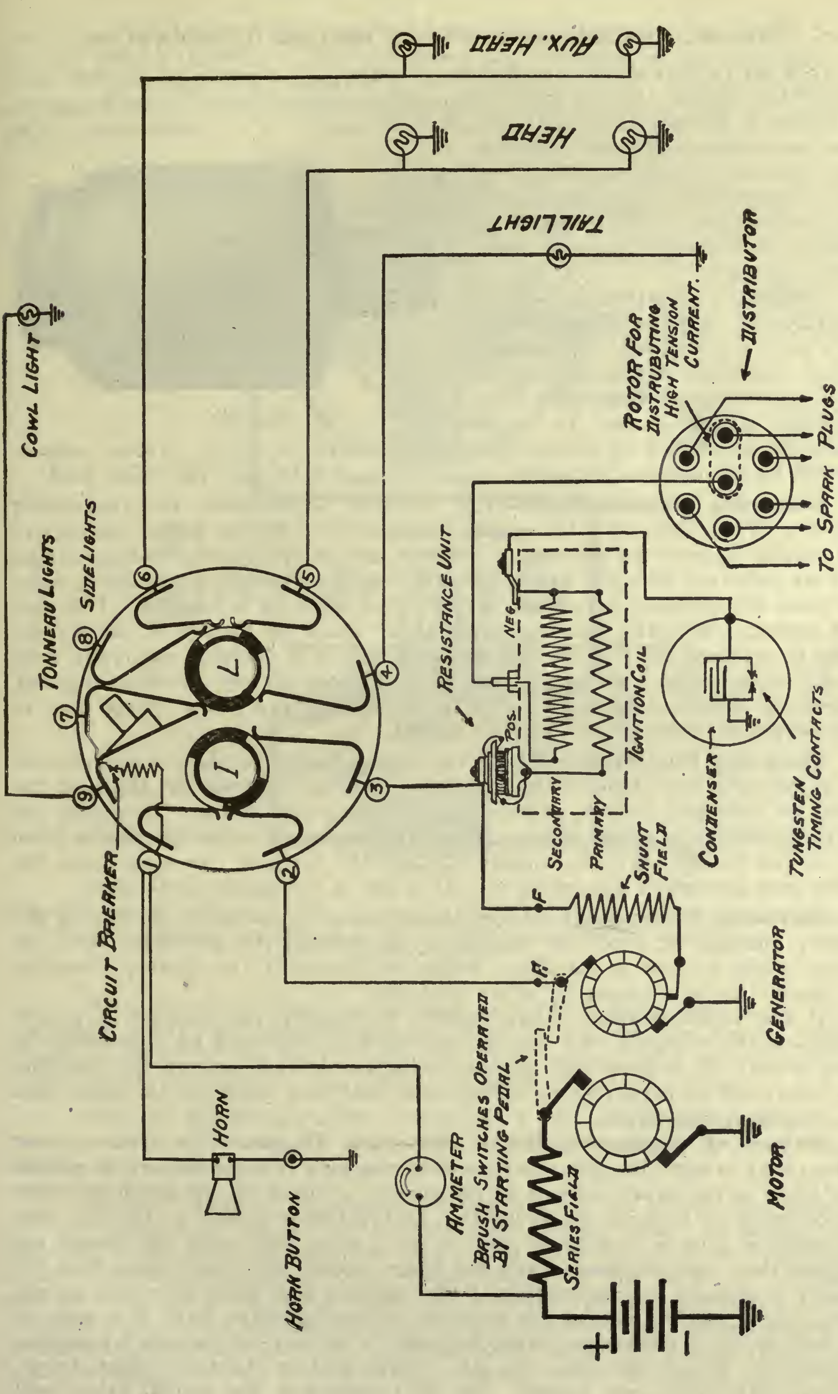

AUX. HEAD
HEAD
TAIL LIGHT
DISTRIBUTOR
ROTOR FOR DISTRUBUTING HIGH TENSION CURRENT.
TO SPARK PLUGS
COWL LIGHT
TONNEAU LIGHTS
SIDE LIGHTS
RESISTANCE UNIT
NEG.
POS.
IGNITION COIL
SECONDARY
PRIMARY
CONDENSER
TUNGSTEN TIMING CONTACTS
SHUNT FIELD
GENERATOR
CIRCUIT BREAKER
HORN
HORN BUTTON
AMMETER
BRUSH SWITCHES OPERATED BY STARTING PEDAL
SERIES FIELD
MOTOR

Fig. 523.

JOB 152. DODGE NORTHEAST MOTOR GENERATOR.

The instrument which is of the single unit type is mounted on the left-hand side of the engine. It is driven by the engine at three times the engine speed. It operates directly from the crankshaft through a silent chain drive. The machine employs only one commutator, one set of field windings, one set of brushes, and one armature for the performance of all its functions both as a starting motor and generating dynamo.

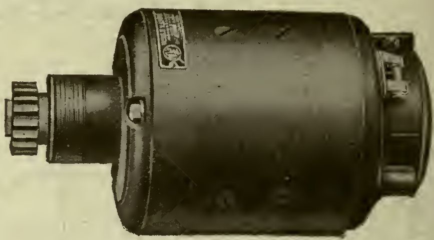


Fig. 524

Starting Characteristics.—While starting the engine the instrument acts as a cumulatively compounded motor, but while serving as a generator it serves as a differentially compounded machine with its output positively controlled by means of the third brush regulating system, supplemented by the differential influence of the series field upon the shunt field.

Generating Characteristics.—The machine is designed for twelve-volt service. When driven by the engine it normally begins to deliver current to the battery as soon as the engine speed is brought to a speed corresponding to a ten miles per hour car speed. At a car speed of sixteen to seventeen miles per hour the standard maximum output of six amperes is reached. This rate will remain practically constant until a car speed of twenty to twenty-one miles is reached, after which the charging rate will decrease gradually until at the upper speed limit of the engine it may be as low as three amperes. Whenever abnormal driving conditions are encountered, some special care to take proper account of them may be needed.

Correcting Overcharge.—Where the battery seems to show a tendency to be chronically overcharged the condition may be relieved by allowing the lamps to burn dim for five or six hours to reduce the charge. To reduce the charge quickly it is a safe plan to permit the battery to crank the engine from five to ten minutes until the charge is materially reduced. In some cases the lamps may be burned dim while the car is left in the garage over night.

Correcting Undercharge.—Undercharge may be corrected by having the battery charged at a service station, or by driving the generator with the engine while the car is standing. Refer to Chapter 11 on battery charging, for instruction in charging by other methods.

If too much trouble is experienced in keeping the battery in proper condition, the charging rate may be decreased or increased by regulating the third brush. In making any change of the third brush setting the charging rate must not be permitted to become less than four amperes nor more than ten as a maximum figure.

Method of Readjusting Starter Generator Output.—The student must always bear in mind the difference between charging rate and generator output. The latter is the entire amount of the current producd by the machine, while the charging rate varies considerably. This variation is due to the fact that the ignition always consumes part of the output and when the lamps are burning they may consume nearly the entire output. At these times then the battery is charged by that portion of the output which is left after the normal needs of the electric system are supplied. Knowing these facts, it is easy to see how the poor driver may easily exhaust the battery by continued cranking, or how the driver, who uses his car a great deal at night for short drives, will encounter the same trouble. On the other hand, the careful driver will

conserve the energy within his battery by properly setting his spark and throttle before cranking. A driver doing much touring in the daytime will likely find a tendency to overcharge the battery. If the remedial measures mentioned above are not satisfactory and the charging rate must be changed proceed as follows:

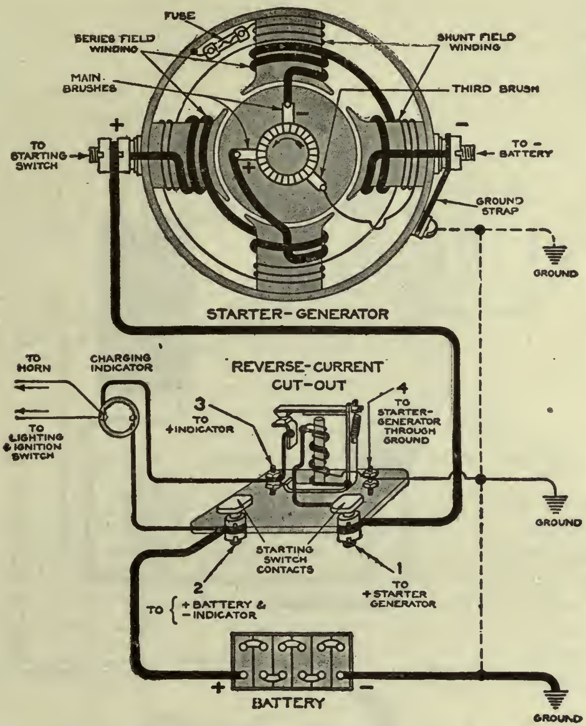


Fig. 525. Circuit Diagram of the North East Model G Starting and Lighting System. Type 3566 Starter-Generator. Type 8100 Starting Switch and Reverse Current Cut-Out.

1. With the starter generator in position to run either on the car or on a test bench, insert a suitable ammeter in circuit to read the total output. Also connect a voltmeter capable of reading at least twenty volts across the two binding posts of the starter-generator to read the generated voltage.

2. Run the starter-generator at 1800 R. P. M.—the speed at which its maximum output is normally delivered—and note the readings of the ammeter and the voltmeter.

3. Consult the output table, page 449, and compare the current and voltage readings obtained in the test with those given in the table. In doing this take into consideration the output variations that occur as the result of changes in the counter-electromotive force (back-voltage) of the battery. To take these variations properly into account, first ascertain the approximate C. E. M. F. of the battery by measuring the starter-generator termnal voltage, which is its practical equivalent; and then, referring to the table, compare the observed current reading with the corresponding standard value of current to be ex-

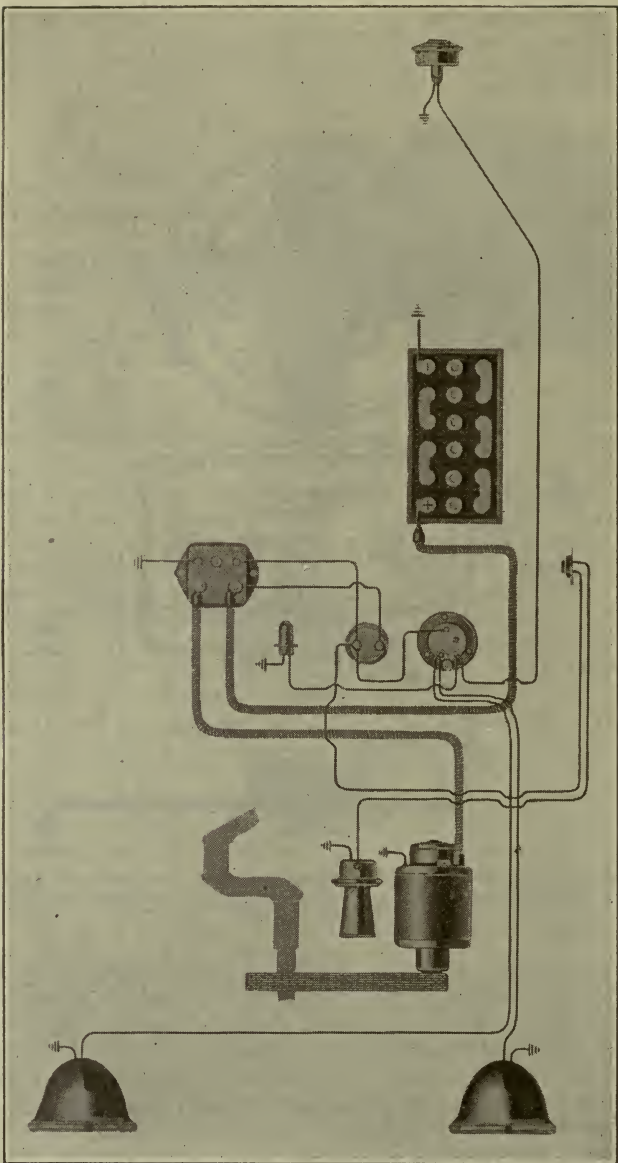


Fig. 526. The North East Model G Starting and Lighting System as applied to the Dodge Bros. Motor Car.

pected at the actual voltage in question. Should the test reading be thus found to differ from the equivalent standard reading, due allowance for the fact must be made in re-adjusting the machine.

Variations in Starter-Generator Output Due to Changes in Battery C. E. M. F.

Starter-Generator Output Amperes	Battery C. E. M. F. (Starter-Generator Terminal E. M. F.) Volts	Starter-Generator R. P. M.
5.5	12	1800
6	13	1800
6.5	14	1800
7	15	1800
7.5	16	1800

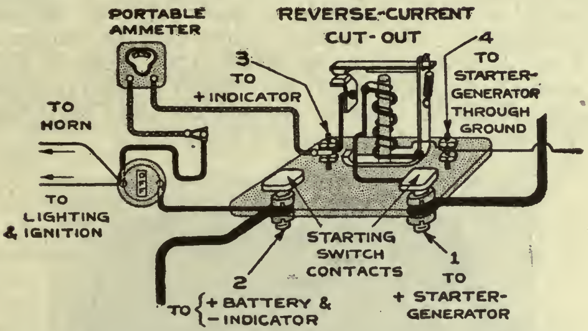


Fig. 527. Ammeter Connections for taking Output Readings.

4. Refer to Fig. 528 showing the Brush Rigging. After ascertaining the true output, shift the position of the third brush until the required modification in the setting is obtained. This is to be done in the following manner: Release the third brush plate clamp (8757) by backing off the clamp screw (4069) one or at most two turns. Then turn the adjusting pinion stud (8035) slowly until the desired output is registered by the ammeter. The stud should be turned in a **counter-clockwise** direction **to reduce** the **output,** and in a **clockwise** direction **to increase** it. The output must never be reduced below

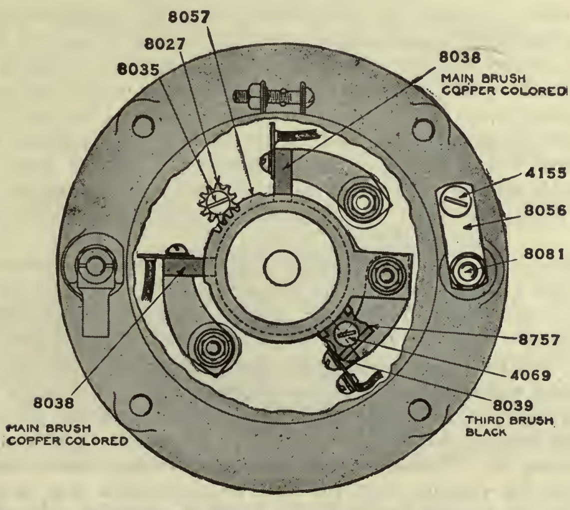


Fig. 528. Dodge Northeast Brush Rigging.

a value equivalent to four amperes at 1800 R. P. M. at a battery C. E. M. F. of fifteen volts, nor must it be raised above a maximum equivalent to ten amperes at the same battery voltage. As soon as the proper setting is obtained, lock the third brush plate again by tightening the clamp screw. Then as a precautionary measure against having disturbed the setting while locking the clamp, note the instrument readings once more after all adjustments have been secured.

5. Before the operation is to be considered finished, the starter-generator must be given a final test by running it for fifteen or twenty minutes at a constant speed of 1800 R. P. M. During this time the readings of both the instruments should be watched closely to make sure that the new setting is accurate and permanent. The machine should then be subjected to a brief varying speed test by first lowering its speed to 700 or 800 R. P. M. and then raising it to approximately 3000 R. P. M. Finally a general inspection of the entire equipment should be made to see that no other parts have been disturbed while the output re-adjustment was being made.

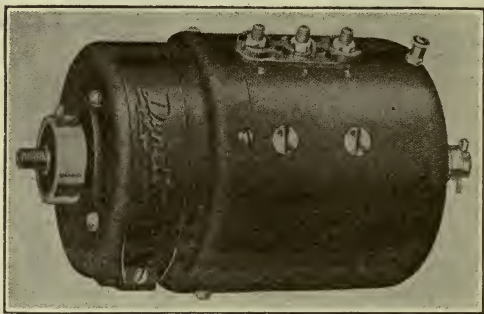


Fig. 529. Dyneto "K1R" Motor Generator, as used by H. H. Franklin Mfg. Co.

JOB 153. DYNETO SYSTEM AS USED ON THE FRANKLIN CAR.

The Dyneto System is of the single unit type. A light weight efficient motor is permanently connected to the engine by means of a silent chain drive which operates the generator at two and one-half to three times engine speed. The student will want to note this feature individual to this system. No over-running clutch is used to secure a starting hold for the starting motor. Neither is there a cut-out employed. The entire system consists of the starter generator, a twelve-volt battery, and the switch. The three units are connected by a very simple wiring system consisting of two wires from the motor generator to the switch, one wire to the battery, and one wire from the battery to the switch.

Operation.—The switch shown in Fig. 530 should be placed on "start." It is left in this position unless the battery is fully charged, or if the car is being used for long or fast runs, in which cases the switch lever is moved back to "neutral" and left there. With the switch on "start," the Dyneto operates as a starting motor spinning the engine from 125 to 200 R. P. M. After the engine starts to run under its own power and above a speed corresponding to car speeds of seven to eight miles per hour the voltage generated is greater than that of the battery and flows to, rather than from, the battery thereby charging it. Whenever the car speed drops below seven or eight miles per hour, the voltage from the battery overcomes that of the generator, and the current flows into the machine from the battery causing it to motor

and help drive the car. At extremely low car speeds the system prevents the motor from becoming stalled. The lower the car speed the more power available from the Dyneto system.

Fig. 530. Franklin Dyneto Switch.

Construction and Care.—The bearings are of the annular ball-bearing type. Keep them clean and apply a little oil each week. The brushes are mounted in their holders which are in turn mounted on a molded bakelite rocker arm. This is accessible through a large hand hole provided for the purpose.

All parts about the unit should be kept clean and all connections tight. The brushes should be examined once in a while. If the commutator is dirty and causes sluggish action of the starter it should be cleaned with a piece of fine sandpaper. Clean the brushes in gasoline. In replacing them they must be returned to their original holder and their exact former position. Do not place with the wrong side up or they will not fit the commutator. Replace worn-out brushes with Dyneto brushes only.

Failure to Start.—If the unit will not operate, turn off the switch, and turn on the lights. If, on attempting to start with the lights on, they do not dim, this is an indication of an open circuit in the starting wires. Examine switch connections, terminals and brushes; also the battery. If there is a drop in the brilliance of the lamps and the dyneto system fails to start, the trouble may be due to loose connections, a rough or dirty commutator, brushes worn-out or not well fitted to the commutator, weak springs, grounded or defective armature or field windings. Refer to tests in Job 160 to Job 188 to learn method of tracing out trouble,

Failure to Generate.—The trouble will probably be found in an open shunt

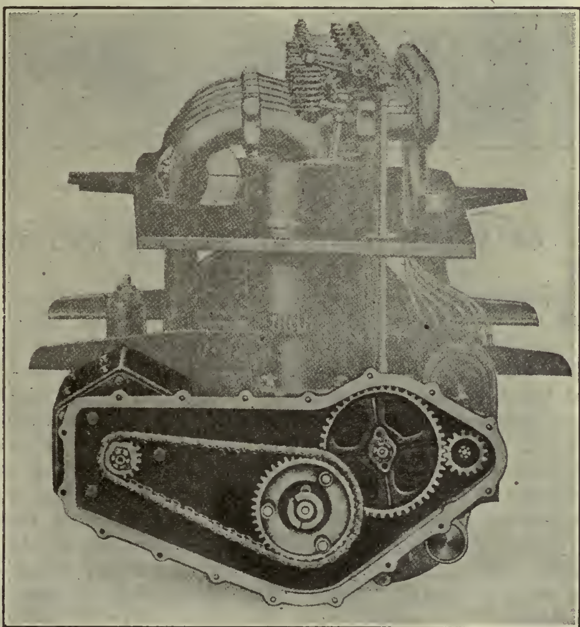


Fig. 531. Franklin Engine with Dyneto Electrical Equipment.

field circuit. In Fig. 533, showing the wiring diagram, the circuit may be traced out from the negative pole of the battery to post 1, through half of the series winding to the negative brush, through a part of armature winding to the third brush, through the shunt field winding to post 3, through the starting switch, if there is one, to the positive side of the battery. The shunt circuit mentioned above may be tested independently of the main circuit by removing the wire from post 2 so as to cut out the main armature circuit, and setting the starting switch on start. If the shunt circuit is complete a bright spark will be made when the wire is removed from post 3. If no spark occurs, look over all the wires and connections and an open circuit will be found. Connect the ammeter for this test as shown in the illustration.

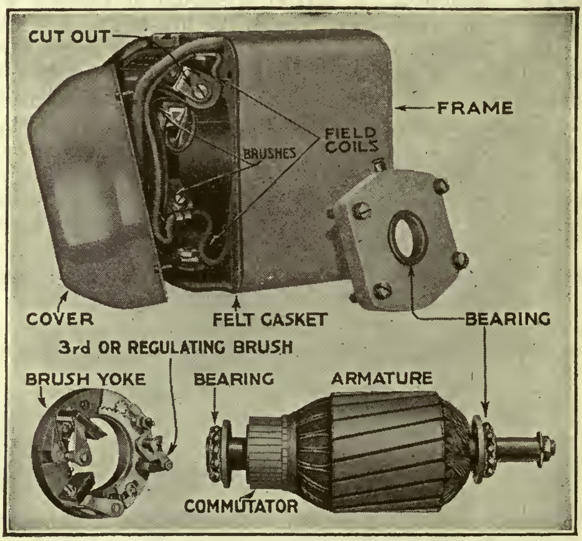


Fig. 532. Gray & Davis Generator and Cut-Out.

JOB 154. GRAY AND DAVIS GENERATOR AND CUT OUT.

Dynamo (Generator).—The dynamo is of the shunt wound type, and is thus classified because its field windings are connected in shunt with, or across, the armature. The fields are connected in series, one side being connected to the positive brush and the other to the third or regulating brush.

The third brush system of regulation is used, thus insuring protection to the battery and lamps at high operating speeds. The dynamo cut-out is shown in Fig. 532 as it is mounted inside the machine. It closes the circuit when the dynamo output is great enough and opens the circuit when the generating speed is insufficient to charge the battery. The shunt winding of the cut-out is connected across the dynamo brushes. This is also called the voltage coil. The series or current coil assists in holding the contacts firmly together.

Lubrication.—The bearings should receive oil every week or every 200 miles. Use a high grade motor oil. Place from eight to ten drops in each of the oiling places. Be very certain to replace the oil covers in order to exclude all foreign substances. Do not assume that the oil is reaching the bearings, but make absolutely certain. Overflow of oil at the oiling places is

WIRING DIAGRAM

Types A and B Instruments

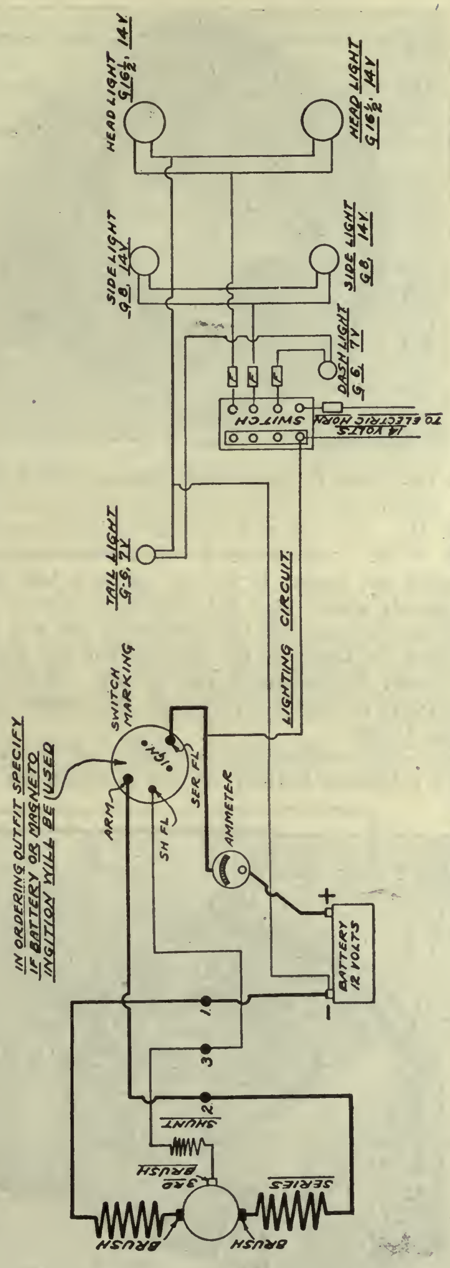


Fig. 533. Franklin Dyneto Technical Wiring Diagram.

no indication that the bearing has oil. At times oil passages to bearings will clog.

Speed and Output.—The dynamos are designed to be driven at engine speed or one and one-half times engine speed. The first delivers its full out-

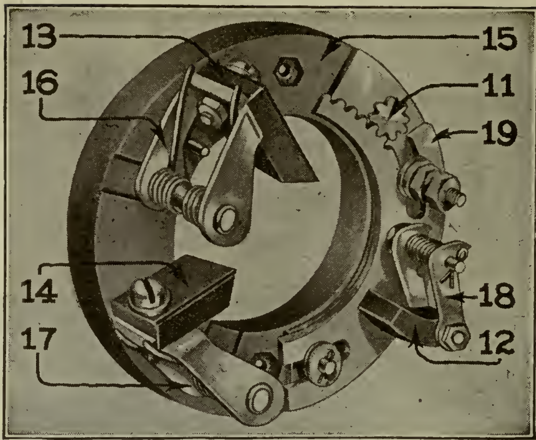


Fig. 534. Gray & Davis Brush Rigging—Third Brush Type.

put at 500 R. P. M. The one and one-half engine speed machine delivers full output at 650 R. P. M. In either case this corresponds to a car speed of from ten to twelve miles per hour. If the car speed is less than this, the output is also less. At speeds above this the maximum output is maintained. If no current is used for lighting, all the generated current excepting that needed for ignition is used for charging the battery and the ammeter will show practically the full output, as flowing to the battery. When the lights are burning the charging current is reduced, although the output is more than sufficient to burn all of the lamps.

Other causes which will result in a falling off of the amount of the charging current are a sulphated battery, or one in which the battery gravity is low.

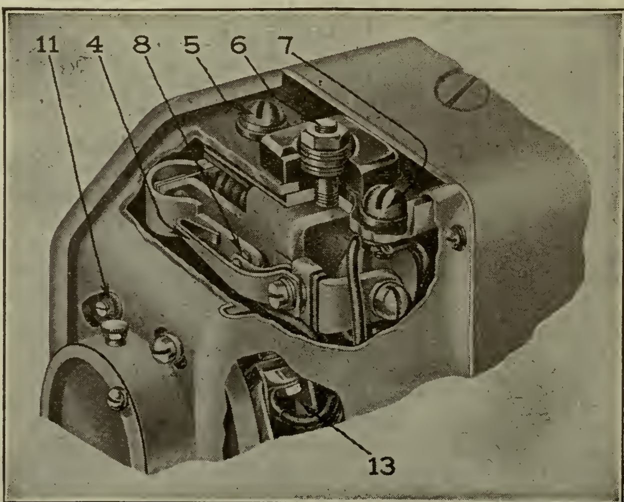


Fig. 535. Cut-out Housed in Dynamo. Gray and Davis.

This is due to the increased internal resistance when a battery is in poor condition.

Operation.—To determine if the dynamo is functioning properly, the mechanic should observe the ammeter carefully. With lights off start the engine running. Increase the speed very gradually. If the ammeter begins to register at a speed corresponding to seven to nine M. P. H., it indicates that the automatic cut-out is cutting in (closing) at the correct time. As the speed

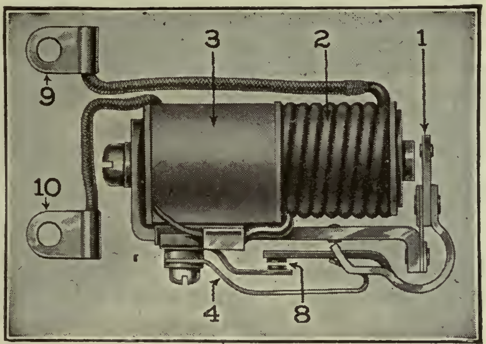


Fig. 536. Gray & Davis Cut-out—Used on Third Brush Dynamo.

is increased the ammeter should register from twelve to fifteen amperes at a car speed of thirteen to eighteen miles per hour. Above eighteen miles per hour and at high speeds the ammeter will show a gradual falling off of the output. This is approximately ten amperes at the higher speeds.

The engine speed should next be decreased as gradually as it was formerly increased all the while watching the ammeter. If, as the ammeter shows a discharge of 0 to 2, the hand suddenly returns to 0, the indication is that the cut-out is opening the circuit properly. However, if the ammeter hand indi-

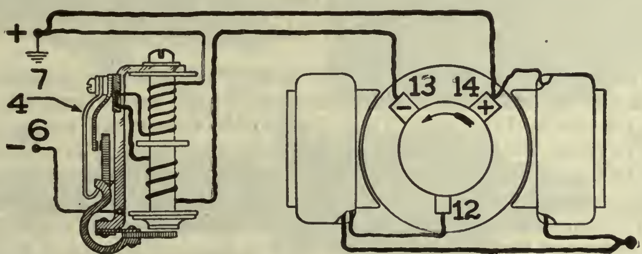


Fig. 537. Gray & Davis Internal Wiring, Third Brush Dynamo.

cates a decided discharge, or should fail entirely to return to 0, the indications are at least a sluggish opening of the points and possibly burned aud stuck contact points in the cut-out.

If the ammeter fails to indicate any charge when the engine is speeded up, the first point is to determine whether the cut-out, dynamo, or wiring is at fault. The wires between the battery and dynamo should be examined. The battery terminals are very frequently at fault. The brushes and commutator should be examined next. The brush holders are equipped with stops which prevent the brush wearing down beyond a certain point. Refer to Job 189 for further instructions. Failing to have eliminated the trouble, the next

step is to connect a wire from the negative dynamo brush 13 in Fig. 537, to dynamo terminal 6. With the engine operating at a 12 M. P. H. speed the cut-out is out of the circuit. An indication of charge and discharge then appearing on the ammeter as the engine is operated would place the fault with the cut-out. However, if the ammeter fails to register the fault is in the generator. Go carefully over all brushes, terminals, fuses, and wiring. Failing to correct the trouble, the machine must be tested with the Faultfinder or some similar instrument as indicated in Jobs 174 to 188.

The car must not be operated with the battery removed unless proper precautions are taken. In this case the method recommended is to raise one of the brushes from the commutator and tie it in that position. This prevents the generator building up an excessive output and voltage with the attendant dangers of burned and damaged parts.

Adjusting Third Brush.—Fig. 534 shows the yoke with the two main brushes 13 and 14. The third brush is indicated by 12. When attempting to adjust the third brush to secure an increased or decreased output an ammeter must be in line, either the one on the dash or a portable one. The battery should be fully charged. The adjustment is secured by turning pinion 11, which is provided with a slot for a screw driver blade. This is shown in Fig. 535 on the outside of the housing. A very slight turn will affect the output very materially. Turning to the left will increase the output, and to the right will decrease the charging rate. The speed at which the driver operates his car has much to do with the output. If the car is driven regularly at high speeds the tapering off or falling off due to the armature reaction may be partially overcome by setting the third brush for a low charging rate at a low engine speed. This will delay the armature reaction and the result will be that the maximum charging rate will come at a relatively higher car speed resulting in a greater output.

The internal wiring diagram is shown in Fig. 537.

JOB 155. GRAY AND DAVIS STARTING MOTOR TWO UNIT SYSTEM.

The starting motor is the link between the battery and the engine. In cranking the engine it converts the electrical energy drawn from the battery into mechanical energy.

Electrically, it is connected to the battery with heavy cables. Mechanically, it is connected to the engine through a gear reduction. The principal parts are shown in Fig. 539. This illustration shows the automatic pinion shift type (Bendix Drive). Mounted on the armature shaft is a sleeve having screw threads, with stops on either end to limit the travel of the pinion. The pinion has internal threads making it a smooth running fit on a threaded sleeve. The pinion is weighted on one side. This sleeve is connected to the motor shaft proper through a spring attached to a collar pinned to the motor shaft.

Normally the pinion is in a demeshed position. When the starting switch is closed, by pressing down on it, the armature of the machine immediately starts rotating. Since the threaded sleeve is connected to it through the spring, it is also set in motion. The motor pinion being weighted on one side does not start rotating immediately, but moves endwise. This endwise motion causes it to mesh with the teeth cut on the flywheel. When the limit of its travel endwise is reached, the pinion must turn with the sleeve and armature. The spring acts as a cushion while cranking against compression. It also breaks the severity of the shock in case of backfire.

When the engine begins to operate under its own power, the increased speed of the fly wheel causes the engine to attempt to drive the starting

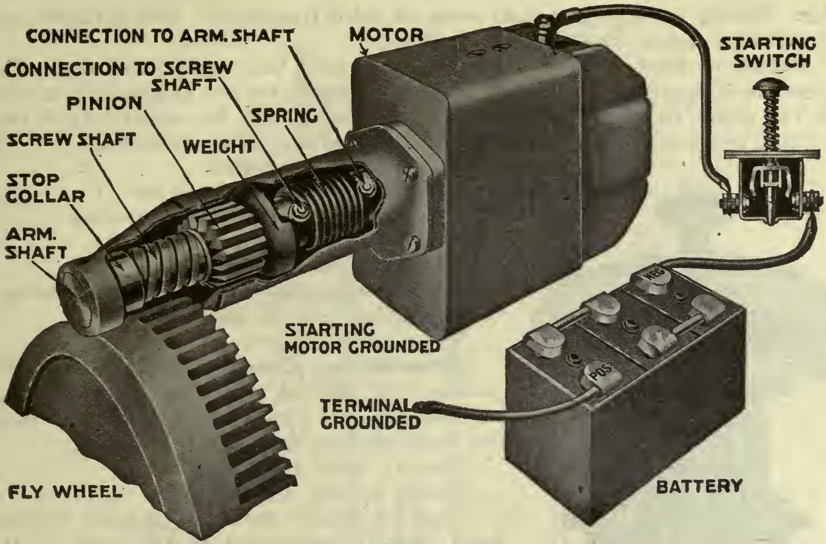


Fig. 538. Gray & Davis Starting Motor Application.

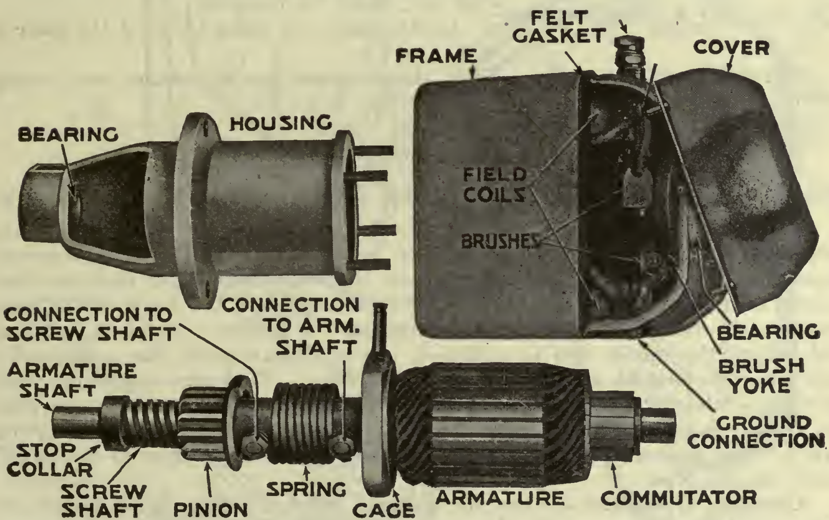


Fig. 539. Gray & Davis Motor Parts. Outboard Automatic Pinion Shift Type.

motor. This results in the pinion being thrown out of mesh since no power can be transmitted backward until the pinion is against the other collar. At this point it is out of mesh. The centrifugal effect of the weighted side of the pinion causes the pinion to be maintained out of mesh until the armature has come to a stop. It is needless to emphasize the necessity of removing the foot to permit the switch to open as soon as the engine is operating under its own power.

Lubrication.—The starting motor must be oiled regularly every two weeks. Eight to ten drops of light motor oil should be placed in each of the oil recept-

acles. Sliding surfaces and rods must be oiled frequently. Use kerosene on the threaded motor shaft to keep it clean.

Failure to Start.—If the starting motor cranks the engine when the starting switch is depressed to the full limit of its travel, but the engine fails to fire and run under its own power, the starting pedal must be released after ten to fifteen seconds. The cause of failure may be any of the following:

Fuel supply exhausted.
Ignition switch not turned on.
Ignition wires not firmly connected.
Spark plugs defective.
Cylinders need priming.
Cylinders flooded from too much priming.
Carburetor out of adjustment.
Poor grade of fuel.

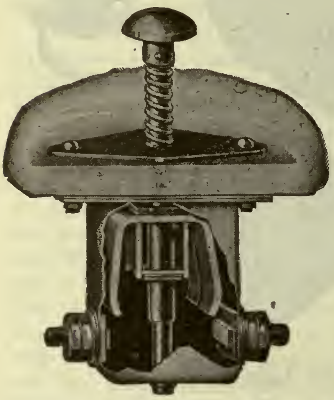


Fig. 540. Gray & Davis Starting Switch.

Reasons for Cranking Failures.—If depressing the starting pedal fails to cause the starting motor to rotate and the engine to turn the fault may be any of the following:

Battery weak or discharged.
Loose battery terminals.

Starting switch not making good contact when pedal is depressed to the limit of its travel. To remedy this press blades out slightly. Refer to Fig. 540.

Crank engine by hand to see if the fault is in it.

Examine motor brushes. They should make good contact and swing freely.

See that commutator is clean.

See that the pinion is not stuck on the threaded sleeve.

JOB 156. HUDSON DELCO MOTOR GENERATOR SINGLE UNIT.

The Delco single unit used on the Hudson engine is typical of Delco equipment. The same armature serves for both starting and generating. However, the windings are separate and the commutator on the rear end is used only for the generator while the commutator on the front end is used only for the motor as it operates in starting the engine. A set of brushes, with which the motor end is equipped, are in contact with the commutator only while the cranking effort actually takes place. This prevents undue wear on them while the machine is used for the work of generating and recharging the storage battery. The car is not equipped with the usual type of starting switch. The raising and lowering of the brushes is the equivalent of the switch action in this case.

Cranking Operation.—When the starting pedal is depressed, it causes the motor clutch to engage with the teeth of the fly-wheel and with the motor pinion gear. Connected to the pedal mechanism is the brush controlling mechanism. When the starting pedal is depressed, the brushes are allowed to come into contact with the commutator. This then permits the current to flow from the positive terminal of the storage battery to the series winding of the motor, to the upper motor brush, through the armature to the lower brush, through the lower brush and frame of the car to the negative terminal of the battery. It is seen how the movement of the starter pedal thus connects the motor to the engine and at the same time closes the switch which in this case is the motor brushes. The wiring diagram, Fig. 542, shows the motor brushes lifted. The cranking circuit may be traced out on the diagram.

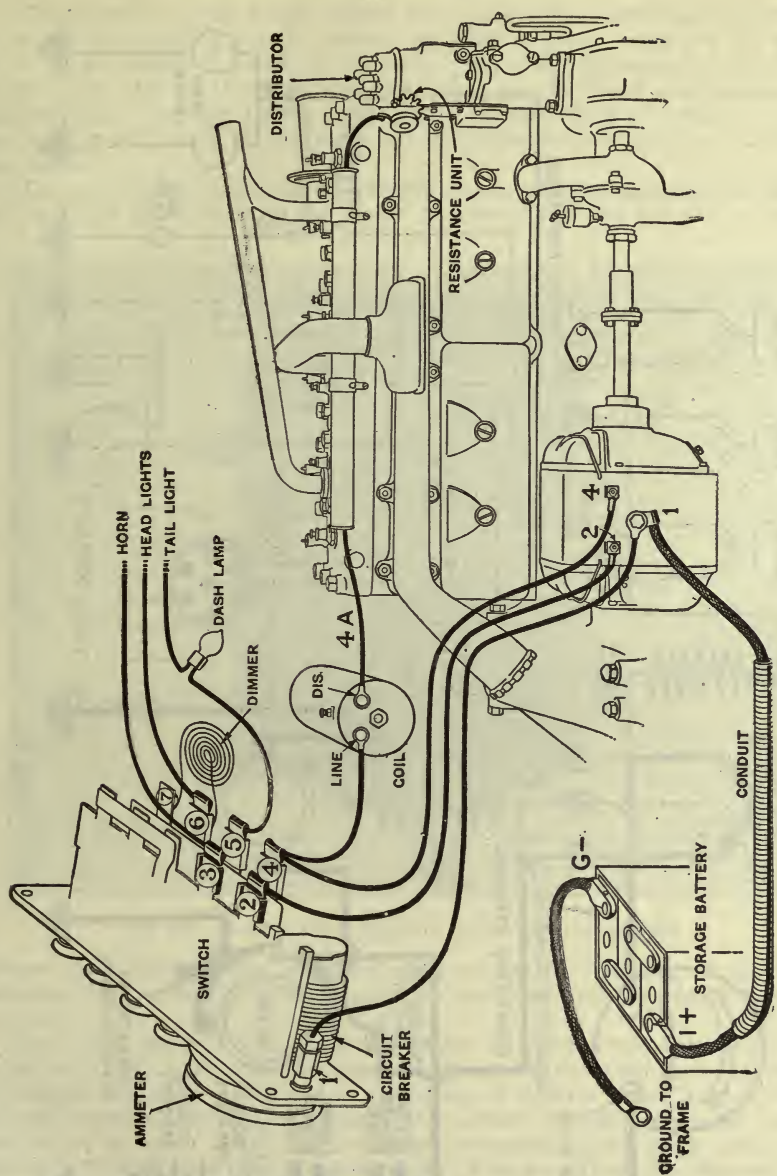


Fig. 541. Hudson Delco Wiring Diagram.

Fig. 541 shows the actual wiring necessary to connect the motor to the battery. As stated previously the negative brush is grounded as is also the negative battery terminal. Fig. 543 shows the motor commutator and the brushes, together with their springs and operating pin.

Operating as a Generator.—When the ignition switch is closed, the generator will start motoring. This is due to the fact that no automatic cut-out is employed, and the action of closing the ignition switch closes the charging circuit as well. Since the pressure of the battery is thus admitted to the

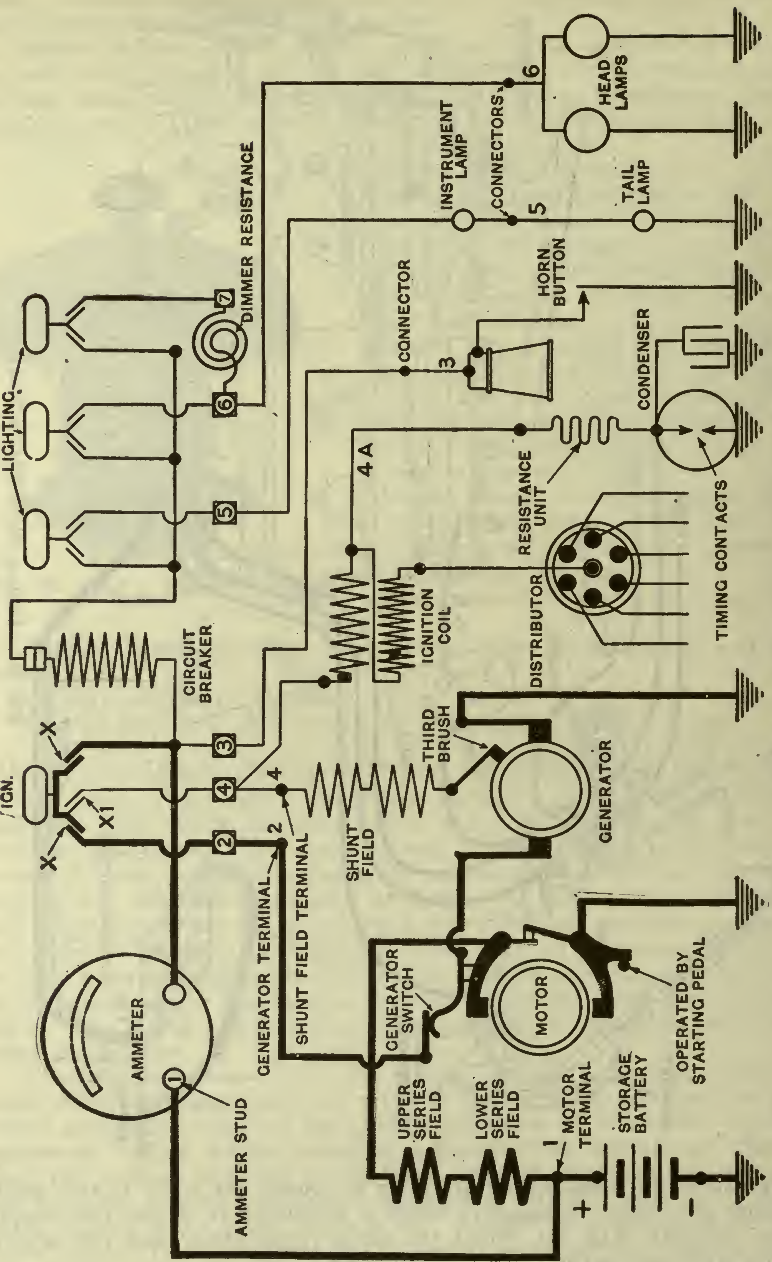


Fig. 542. Hudson Delco Circuit Diagram.

charging circuit, current is caused to flow to the generator from the battery. This flow of current amounting to four or five amperes is sufficient to cause the generator armature to rotate at a slow speed. In some Delco models this is evidenced by the ratchet-like noise of the over-running clutch.

The purpose of the design which incorporates the motoring armature is to insure the starting motor pinion engaging properly with the fly-wheel teeth as the starting pedal is depressed. As noted previously, the same action which throws the gear into mesh with the fly-wheel also applies the starting motor brushes to the commutator of the starting motor. A third operation is performed by this same operation, and that is opening the generator switch.

The generator switch which is shown in the wiring diagram, Fig. 542, as well as in the illustrations of the motor generator, Fig. 543 and 544, serves to

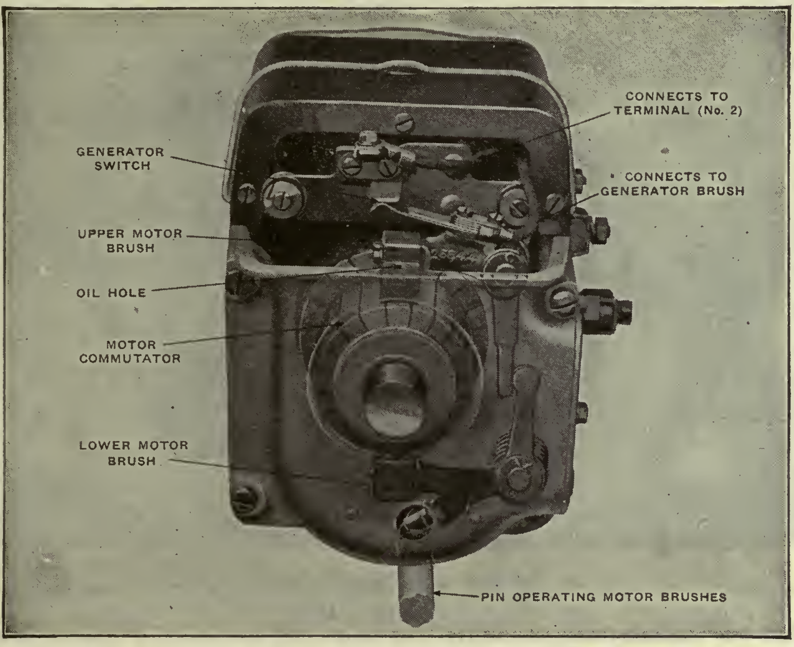


Fig. 543. Hudson Delco Motor Brushes and Commutator.

connect the battery to the generator winding, on the armature, at all times, excepting only when the starting pedal is depressed and the engine is being cranked.

After the engine starts operating under its own power, the generator switch is closed as the pedal is released and current flows through the charging circuit. As long as the engine continues to operate above a speed sufficient to overcome the battery voltage the current will flow from the generator to the battery. When the car speed or engine speed drops down, the current will reverse in the charging circuit and flow from the battery. To stop the flow of current within the circuit, it is necessary to open the ignition switch, which at the same time opens the shunt winding of the generator.

Regulating Generator Output.—The Hudson Delco equipment is controlled by the third brush method. The position of the brush on the commutator controls the output. The output is regulated at the factory and should be satisfactory for the average driving conditions.

If it should become necessary to increase the output, first remove the cover plate over the third brush. The next step is to loosen the two set

screws in the arm of the third brush and move the brush to the right (looking at the front end of the generator). A small movement will make quite a difference in the charging rate. To decrease the output move the third brush to the left. Be certain to set up the screws snug and tight, to prevent parts coming out of adjustment. It is also necessary to sand in the brush in its new position. Refer to Job 189 for instructions.

At nine miles per hour the charging rate should be five amperes, at twelve

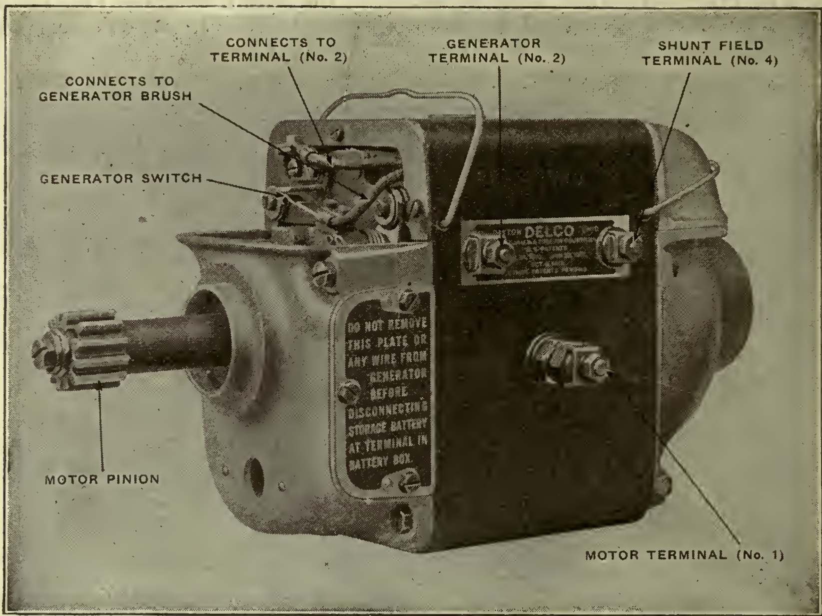


Fig. 544. Hudson Delco Side View of Generator.

miles, ten amperes, and at twenty-four miles the maximum is reached which is seventeen amperes, after which point the output drops off rather rapidly until at 42 miles per hour the output has dropped back to eleven amperes.

The operator must remember that with this system the drain on the battery is two-fold if the ignition switch is inadvertently left on, since the drain is both to the ignition and the generator.

JOB 157. MAXWELL SIMMS SYSTEM.

This system is a twelve-volt single unit type. It is so mounted on the Maxwell engine that the one end of the armature shaft may be used for driving the engine through the starter pinion and the other end receive the power from the engine which drives the machine as a generator. This arrangement is possible due to the fact that the generator drive is one of belt friction.

The generator driving shaft is connected to the small end of the armature shaft by means of a flexible coupling. The forward end of the shaft is equipped with a pulley. The generator is driven at about two and one-half times engine speed by the fan belt. When the motor generator is connected to the fly-wheel pinion, however, the generator speed is about nine times the engine speed. As this connection is a positive one, the fan belt slips on the

generator pulley during the time that the motor is used for starting or cranking the engine. In this manner the use of over-running clutches, or ratchets, is done away with.

Starting Conditions.—Refer to Wiring Diagram Fig. 547 for the numbers and circuits mentioned. Under starting conditions the starting switch plunger is moved forward and completes the circuit between 5 and 6. The same movement connects the starter pinion or meshes it with the fly-wheel gear. This is not shown on the wiring diagram. The path of the current is then as follows:

Starting at the storage battery from terminal 8 the current flows through

Fig. 545. Maxwell Simms Motor Generator.

connection 9 to contact 6, through connector 10, through contact 5, in the starting switch, then to terminal 11 at the generator through the positive brush 14 into the armature to the negative brush 15, through the series winding of the field pole, and thence to the frame or ground of car to terminal 12 and negative pole of the battery.

Charging Conditions.—After the current has flowed from the battery and through the circuit indicated above, thus starting the engine to running under its own power, the foot pedal is released, which in turn demeshes the pinion and opens the switch leaving it in the position shown in Fig. 547. The fan belt drive for the generator now becomes operative. The residual magnetism left in the field poles is sufficient to start the machine generating. Current is generated between the two main brushes 14 and 15. Starting from the third brush 13, the current travels through the shunt field coils to the frame of the motor, through the series field coil, and back through the negative brush 15. This shunted current passing through the field winding produces a stronger magnetic field to be cut by the armature winding, and consequently permits the voltage or pressure to be built up and the output increased. Starting from terminal 11 the current flows through the small wire to terminal 16, through

Fig. 546. Maxwell Simms Yoke, Complete.

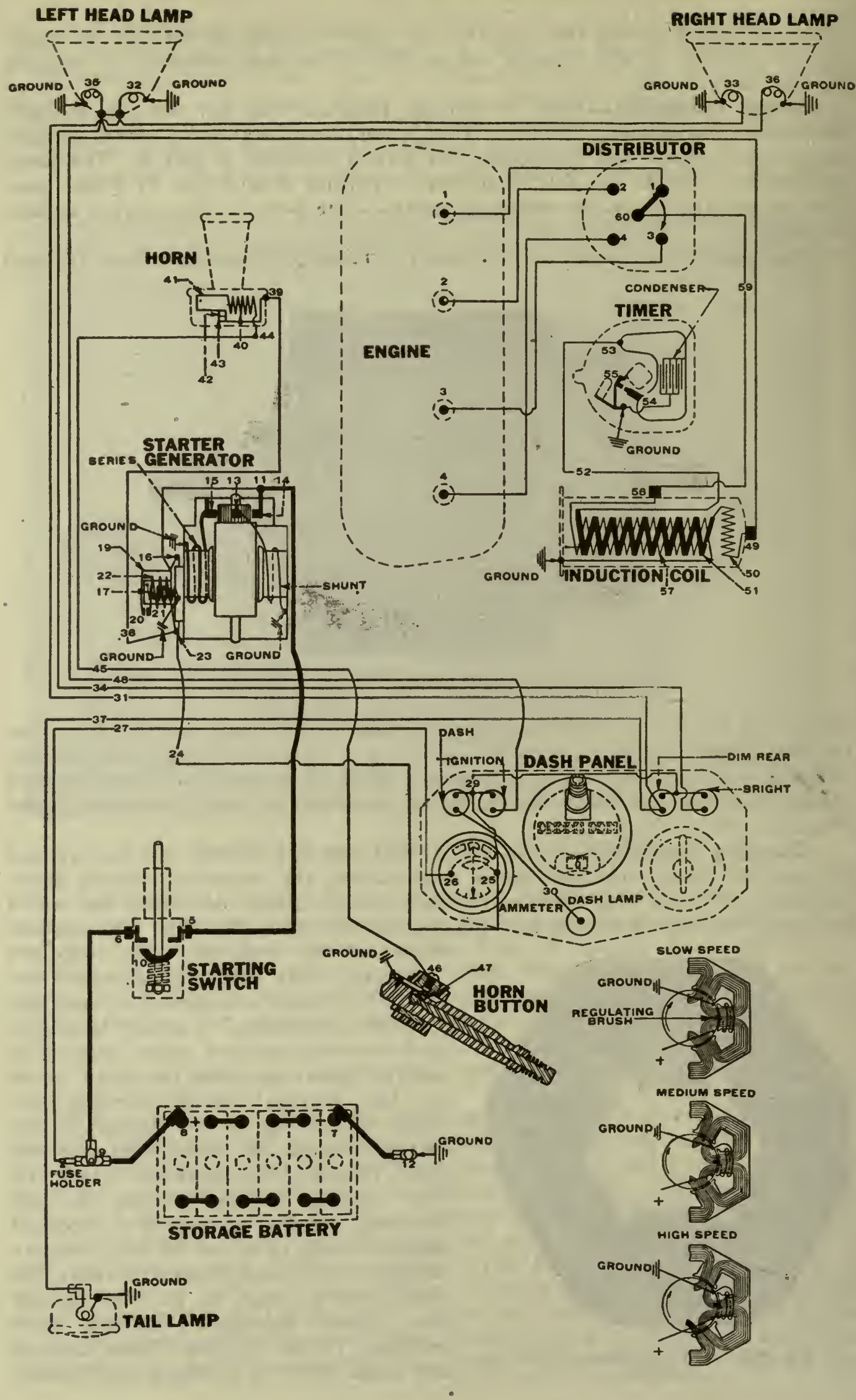


Fig. 547. Maxwell Simms Wiring Diagram.

the voltage coil in the cut-out 17 to the ground. This causes a magnetic action which closes the contact points, whereupon the current will flow through 19, 20, and 21, through the coil 22, through terminal 23, through wire 24 to ammeter terminal 26, through wire 27, through fuse holder, through terminal 9, through terminal 8, through terminals 7 and 12, to the ground, then through the series winding of the generator field and back to the negative terminal, 15, of the machine.

Generator Output Regulation.—Fig. 547 shows three cuts marked Slow Speed, Medium Speed and High Speed. The relative positions of the two main brushes and the third brush are shown. The lines of force are represented by twelve lines for the twelve volts output of the system. These lines do not represent the winding, but the lines of force or magnetism of the field poles, yoke and armature. In the Slow Speed it will be noted that the lines of force are equally divided over the surface of the pole shoe. In the Medium Speed section it will be noted that the lines are distorted in the direction of armature rotation. This is due to the armature reaction as explained in the early part of the chapter. In the section marked High Speed a still greater distortion is shown which is representative of the actual condition in the field.

Fig. 548. Maxwell Simms Brush-Holder, Complete.

If, as stated above, each line is said to represent approximately one volt and there is a total of twelve volts per pole, and the field coil is connected to the third or regulating brush one-half way between the two main brushes, the student will see that the resultant distortion of the increase of speed causes fewer lines of force to be cut, and decreases the amount of current flowing through the field as indicated.

Since the current output is dependent on the three factors, armature speed, armature winding, and field, it is evident that the increase of speed is counteracted by the decrease of the lines of force being cut, as the distorted field insures. Consequently the regulation is inherent. The shunt field is wound for seven and one-half volts, while the armature output is approximately fifteen and one-half volts when the third brush is properly located and the armature running at approximately 1500 R. P. M.

JOB 158. REMY OLDSMOBILE.

As in the case of the Remy Ignition, the Remy starting and lighting equipment is built for a large number of car manufacturers. The Oldsmobile is given here as representative of the Remy line.

Thermostat Control.—The student no doubt understands by this time that the thermostat control is a device of whatever nature which is so arranged to control some other feature of equipment because of certain action within itself, due to heat. In the chapter on Cooling Systems the effect of heat on the thermostat controlling the water circulation was explained. In this case the heat is produced by running a current of electricity through a bit of resistance wire wound on a metal blade. This blade is made up of two metals, one with a great amount of expansion when heated, the other one not subject to much expansion. The result is that, when the current flows through the resistance wire around the blade, they are heated. When heated beyond a certain point the blade, owing to the nature of its construction, will curve, thereby throwing

the points apart and inserting another resistance unit into the circuit which will cut down the output of the generator.

In the Remy this device is used in connection with the third brush control to regulate the output of the generator. It is natural that more current would

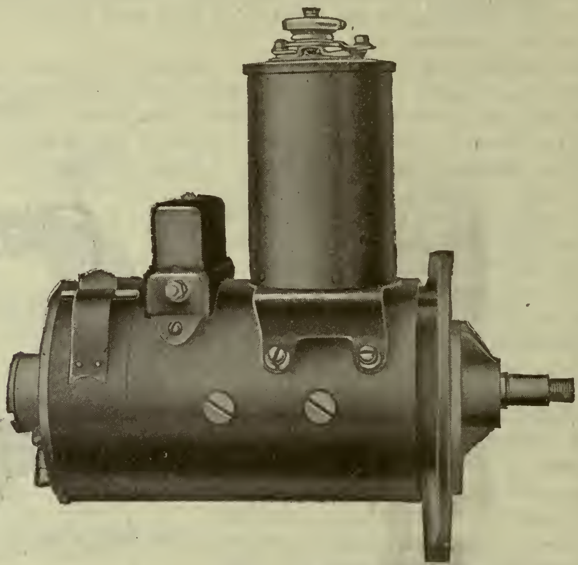


Fig. 549. Remy Oldsmobile Generator with Ignition Coil and Relay mounted on it.

be required in the cold winter months to open the thermostat than in the warm summer months. This is an especially desirable feature since the demand for current both for starting and lighting is much greater in the winter than in the summer. This device then helps to insure a higher charging rate in the winter to compensate for the heavy demands on the battery. The device is entirely automatic and requires no attention. In case of serious damage to it a new unit should be installed.

Third Brush Control.—The output of the generator is high and the thermostat is depended on to prevent overcharging. However, if the battery shows signs of being continuously overcharged, the output may be reduced by means of the third brush screw. This is found on the commutator end of the generator and a slight turn to the left will correct the trouble. Likewise turning to the right will increase the output. This should never exceed twenty amperes. Where the output is too low, look for brush or commutator trouble.

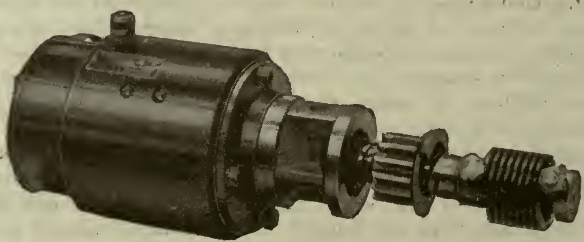


Fig. 550. Remy Oldsmobile Starting Motor.

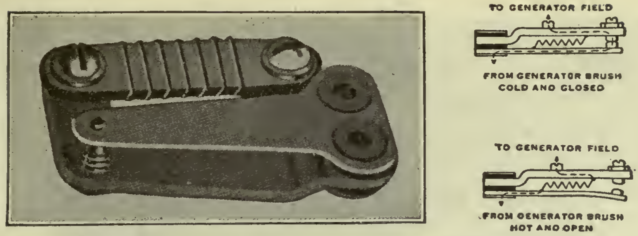


Fig. 551. Remy Oldsmobile Thermostat.

Relay.—This is the automatic cut-out previously described. The Remy relay shown in Fig. 553 consists of the contact points, a movable arm with a spring hinge, and a simple electro magnet. The spring holds the contacts apart when the engine comes to rest. When the generator is being driven at

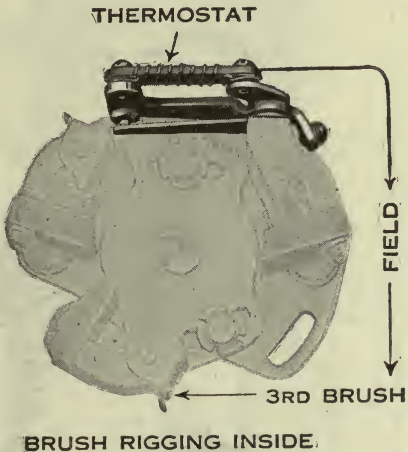


Fig. 552. Remy Oldsmobile Brush Rigging with Thermostatic Control mounted on the inside.

a speed sufficient to develop a voltage equal to that of the battery, the shunt coil on the relay, sometimes called the voltage coil, is energized and the arm bearing the one contact is pulled down to the other, thus closing the circuit through

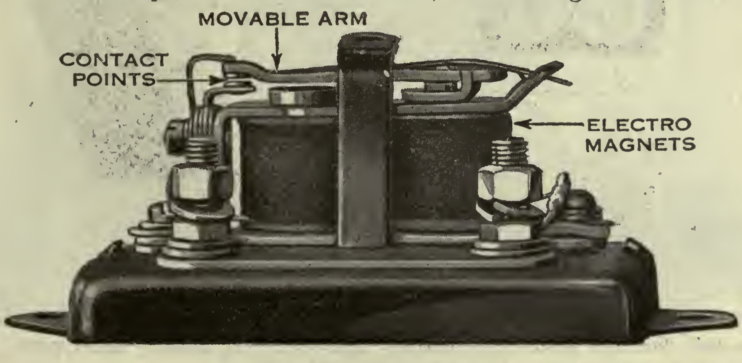


Fig. 553. Remy Relay.

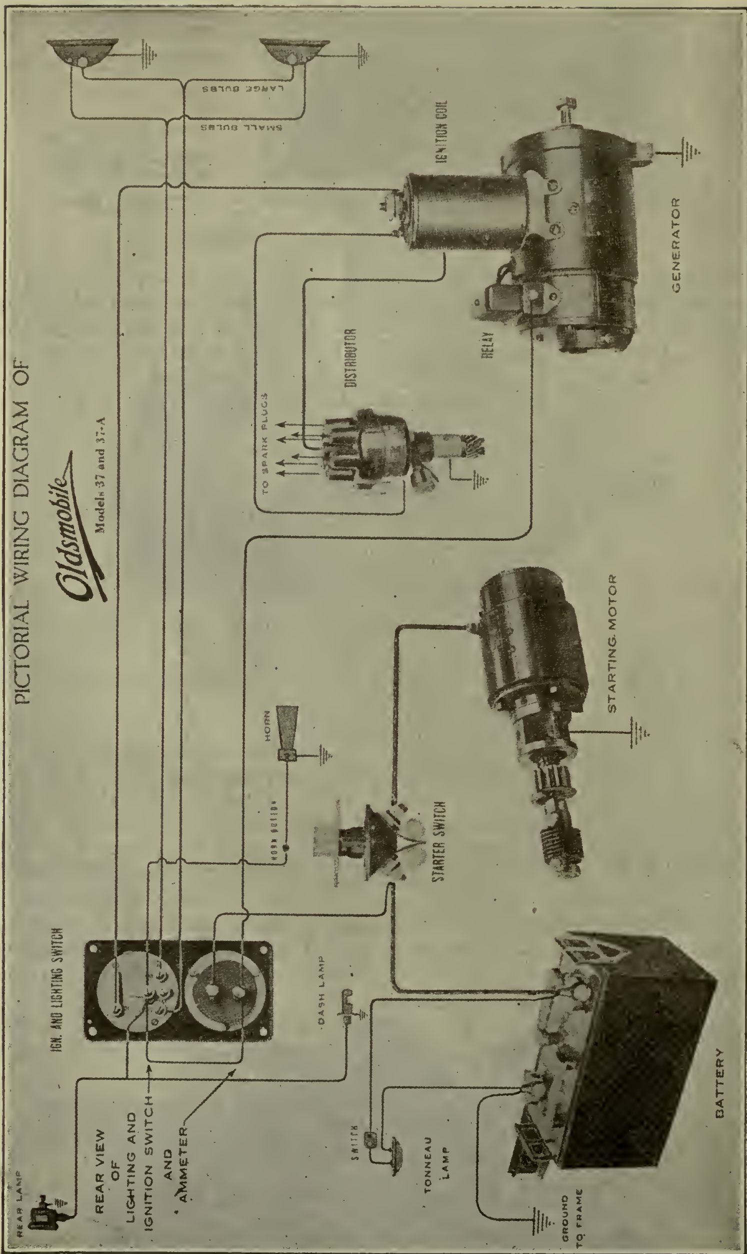


Fig. 554. Remy Oldsmobile Starting, Lighting and Ignition Equipment.

which the current must flow to reach the battery. The relay is provided with a series coil, through which the current flowing to the battery must pass. This insures the contact points being held firmly together.

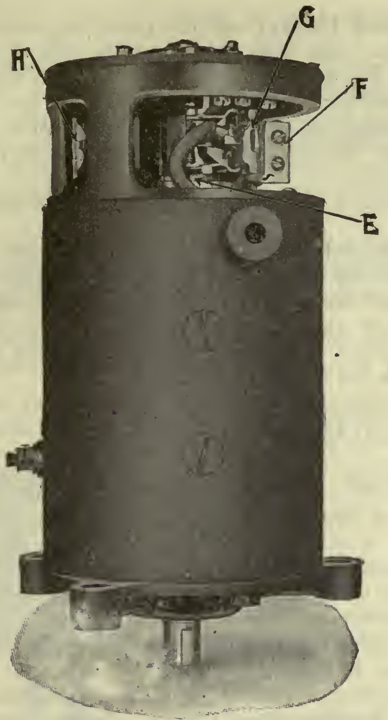


Fig. 555. Studebaker Wagner Generator.

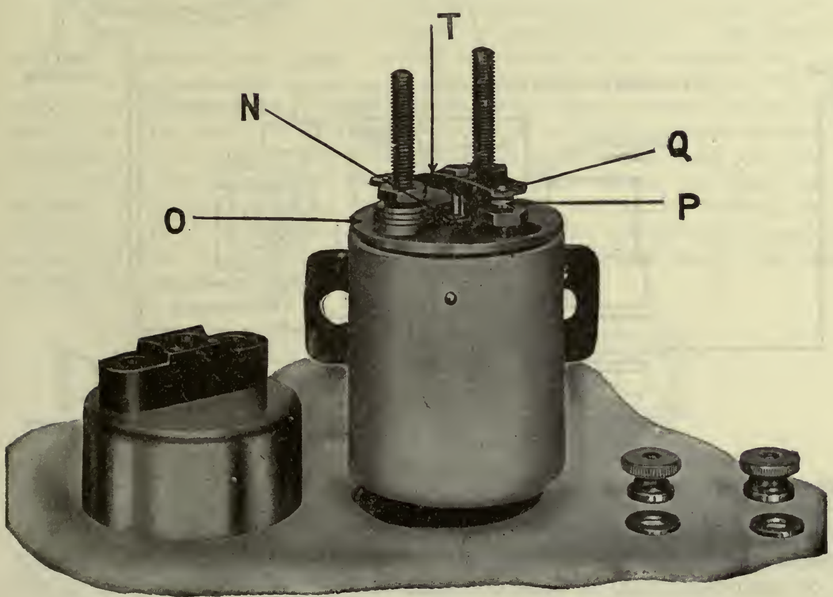


Fig. 556. Wagner Relay Cutout.

Care of Contact Points (Relay).—If the points become worn or dirty, or show a tendency to stick, they may be placed in good condition by passing through them a piece of No. 00 sandpaper. Blow out all dust to allow a clean, flat contact. Use care not to spring the arm, or to change the opening or the spring tension. The spring tension is correct unless there are some unusual circumstances attending. The clearance of the contacts when open is from .015″ to .020″.

Starting Motor.—This is a four pole series wound machine. A Bendix drive is used.

When the starting switch is closed, the motor starts revolving at high speed. The pinion gear, by reason of its inertia, tends to lag behind the rotation of the shaft, thus being thrown into mesh with the teeth cut on the fly-wheel. As soon as the engine starts operating under its own power, the pinion is driven faster than the armature and threaded shaft, and is thus thrown out of mesh with the fly-wheel teeth.

This arrangement permits of a large starting torque, since the armature is running at a high rate of speed when the load comes onto it.

JOB 159. WAGNER GENERATOR.

A unique feature of the Wagner Generator in its application to the Studebaker power plant is the fact that the instrument is so designed, built, and attached as to operate in a vertical position. The Wagner Company manufactures generators which are driven in the more common horizontal position. Fig. 555 illustrates the Studebaker generator.

This instrument is built along the usual third brush regulation lines. One unique feature about the third brush arrangement is that the adjustment is made at the factory and then sealed. The factory guarantee is made void if this seal is broken by anyone other than a Wagner representative in the

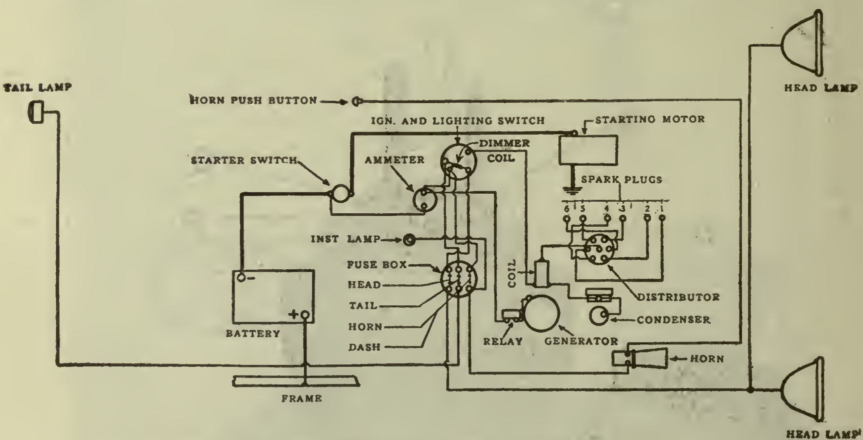


Fig. 557. Studebaker Wiring Diagram.

Wagner factory, or an accredited Wagner service branch. This emphasizes the fact that a properly designed generator requires very little adjustment of output if attendant equipment is maintained and used properly.

Generator Care.—See that the two oil holes receive a few drops of the best oil each 1000 miles of service. Wipe the commutator clean. It is not usually necessary to sand in the brushes, or sand down the commutator for

several seasons' service, but if the work must be done, follow the directions given in Jobs 189 and 190.

Relay Cutout.—This works automatically to cut in the battery at approximately ten miles per hour, and the generator will give the maximum output from seventeen to nineteen miles per hour.

Wiring Diagram.—Fig. 557 shows the Wagner Studebaker wiring diagram. The feature in this diagram of special interest is the junction box where all wires are brought together for proper connection and fuse protection.

JOB 160. INSTRUCTIONS FOR THE USE OF WESTON MODEL 441 FAULT FINDER FOR TESTING AUTOMOBILE ELECTRIC STARTING, LIGHTING AND IGNITION SYSTEMS.

Description of the Instrument.—The Weston Model 441 Fault Finder, illustrated in Fig. 558, consists of an ammeter and a voltmeter mounted in a convenient case.

Connections to the instruments are made by means of cables having clips at one end and plugs with handles at the other end. The plugs are pushed in position through the holes in the marking plate through especially constructed contact clamps.

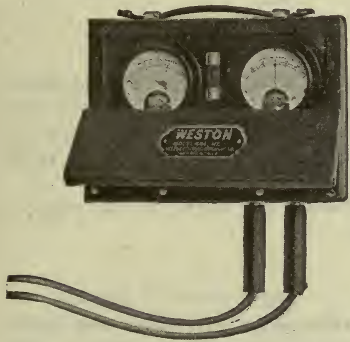


Fig. 558. Model 441 Fault Finder.

The Ammeter.—The ammeter is self-contained, having a range of 30 amperes. The scale is provided with the zero at the center. There are fifteen divisions each side of zero. The value of each division is two amperes.

The ammeter is protected against injury by burn-out by the enclosed glass fuse mounted on top of the instrument case between the two instruments. This fuse is a standard 30-ampere automobile fuse.

The ammeter must always be connected in circuit so that the full current of the circuit under test will pass through it. To make this connection, the circuit is opened at some convenient point and the test clips are attached to the two ends of the break just made.

To trace the direction of the current flow in a circuit by means of the ammeter, it is only necessary to remember that the pointer deflects to the right of the zero mark when the current enters the instrument through the contact marked +, and to the left of the zero mark when the current enters through the contact marked 30.

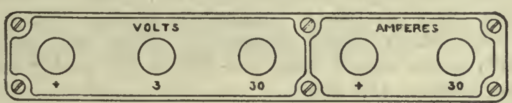


Fig. 559. Marking Plate for Model 441 Garage Testing Instrument.

The Voltmeter.—The voltmeter is a double range instrument. The ranges are 0.2-0-3 volts and 2-0-30 volts. The scale has 30 divisions above zero and two divisions below zero. Each division on the 30-volt range has a value of one volt, and on the three-volt range 0.1 volt.

The voltmeter should always be connected over that part of the circuit

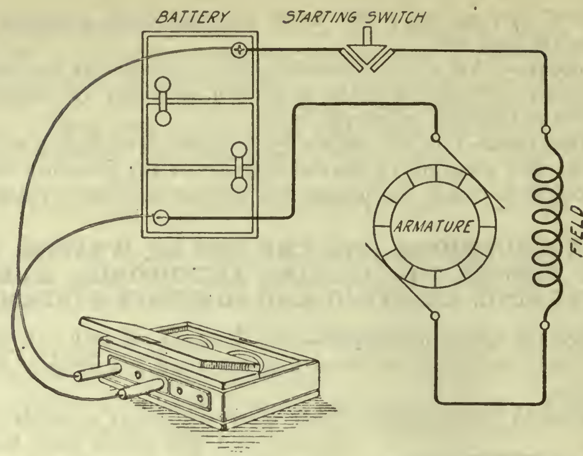


Fig. 560.

across which the voltage is to be determined. When using the voltmeter, connect the plug which is in the (+) hole of the plate on the side marked volts to the positive (+) wire of the circuit, and the other plug to the negative (—) wire, placing the plug in either the hole marked 30 or 3, according to the range to be used.

When connected as just explained, the pointer will move to the right of the zero if the polarity of the circuit is correct.

JOB 161.

When the Starting Motor does not Operate.—To determine the cause, proceed as follows: Carefully examine all connections at the starting switch and at the motor. Also be certain that the brushes of the starting motor are making good contact on the commutator, and that the commutator is clean.

Examine contact surfaces of the starting switch to be sure they are clean and making good contact.

Having eliminated possible causes of trouble, connect the 30-volt range of the voltmeter across the battery terminal as illustrated in Fig. 560. Note the reading.

Case A.—Close the starting switch. Again note the reading. If it is the same as when the switch is open, there is an open circuit either in the starting switch, Job 162, the motor field, Job 163, or the motor armature, Job 164.

Case B.—If on closing the starting switch a small decrease in the reading results, there is a high resistance somewhere in the circuit, which was not located by the preliminary visual inspection. This may exist in the battery terminals, Job 166, in the motor field, Job 163, in the motor armature, Job 164, or in the starting switch, Job 162.

Case C.—If, on closing the starting switch, a large decrease in the reading results, the battery may be exhausted, a short circuit may exist in the starting motor field, Job 168, or in the motor armature, Job 170, or in the wiring, Job 169.

Case D.—If the reading on the voltmeter, when the starting switch is open, is very much below the normal voltage of the battery, one or more cells of the battery may be exhausted or defective, or a short circuit may exist in the wiring between the battery and the starting switch. (Job 169).

JOB 162.

Open Circuit or High Resistance in Starting Switch.—Connect the 30-volt range of the voltmeter to the terminals of the starting switch, Figure 561. If the rest of the circuit is in good condition the voltmeter will indicate the battery voltage; if it does not, trouble exists in some other part of the apparatus. Close the starting switch. An open circuit will be designated by

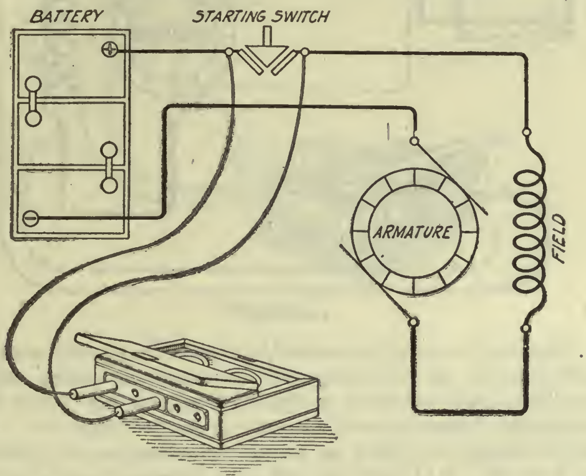


Fig. 561.

no change in the reading. A small change in the reading will indicate a high resistance. In either case, the contacts of the starting switch and all connections in it, or to it, should be carefully examined. Contacts should be cleaned or repaired if found to be poor. If the switch is in good condition the indication will drop to zero on closing it.

JOB 163.

Open Circuit or High Resistance in Motor Field.—Connect the 30-volt range of the voltmeter to the ends of the field coils as shown in Fig. 562. Close the starting switch.

An open circuit in the field coil will be indicated by the reading of the instrument being equal to the battery voltage. Try all sections of the field. A good field will be indicated if the instrument reading is zero or nearly zero. A reading which is somewhat lower than the battery voltage and not near to zero indicates a field of high resistance. Look for loose connections between sections of the field if high resistance is indicated.

JOB 164.

Open Circuit or High Resistance in Motor Armature.—Connect the 30-volt range of the voltmeter to the armature terminals as shown in Fig. 563. Close the starting switch. If the voltmeter shows a reading equal to the voltage of the battery, the armature is open. A good armature will be denoted by a very low reading. A high resistance will be denoted by a reading somewhat lower than the battery voltage but considerably above zero.

An open circuit may be in the brush leads. These should be carefully

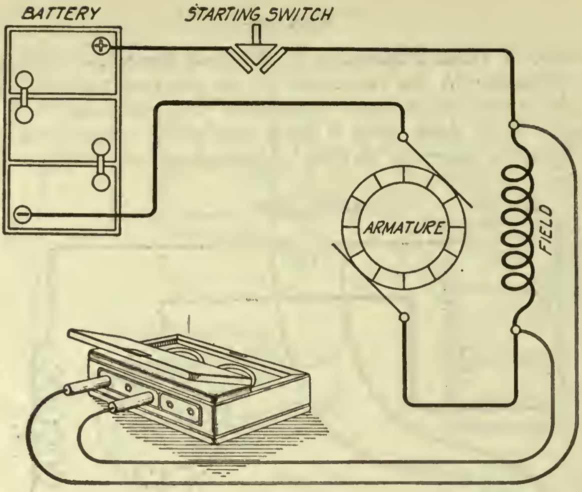


Fig. 562.

examined. Other causes may be burned-out coils or broken wires in the coils, or brushes not bearing on the commutator because the spring tension is poor; worn out brushes; brushes stuck in the holders; poorly fitted brushes; high mica; low segments; loose or poorly soldered connections.

If the open circuit is found to be in the armature, the same should be disconnected from the field and one cell of a storage battery in series with a lamp bulb connected to the brushes as in Fig. 564. Connect the three-volt range across the brushes and note the reading. If it is equal to the battery voltage there is an open circuit in both halves of the armature. If it is less than the battery voltage, connect one of the test cables to a segment lying under a brush and the other cable to the adjacent segment as shown in Fig. 564. Move the lead on around the commutator one segment at a time, and if the deflection gradually increases to approximately the value obtained across the brushes, the half of the armature tested does not contain an open circuit.

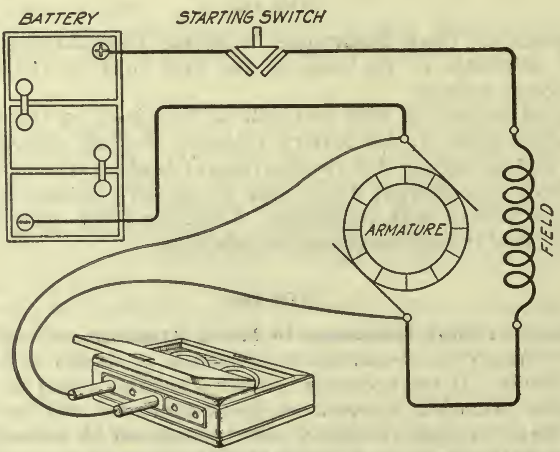


Fig. 563.

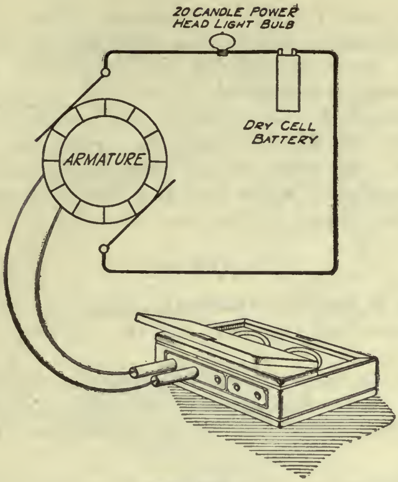


Fig. 564.

If a segment is reached on which the deflection suddenly increases to approximately the value obtained across the brushes an open circuit exists in one or more of the coils included between the test leads. The other half of the armature can be tested in the same manner. In order to test the coils lying under the brushes the armature should be rotated slightly and the test repeated.

High resistance in the armature circuit may be due to broken coil wires which are lightly touching at the break, poorly soldered connections at the commutator bars, poor bearing brushes, and dirty commutator.

JOB 165.

High Resistance in Ground Connection.—Connect the 30-volt range of the voltmeter to the terminal of the battery which is grounded (usually the

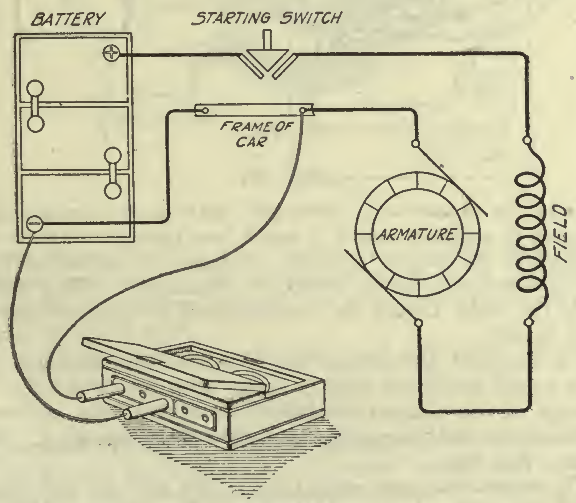


Fig. 565.

negative is grounded), and the frame of the car. When doing this be sure that all paint or other insulating substances are removed and that connection is made to the metal. Upon closing the starting switch no indication will be obtained if the ground connection of the car is good. If it is poor, a deflection will be obtained. To remedy this condition remove the ground connections between the battery and the frame of the car. Clean the connection lead and the frame where the connection is made. Give the cleaned surfaces a coating of white lead and make the connection again, being certain that it is tight. Refer to Fig. 565.

JOB 166.

High Resistance in Battery Terminal.—This may occur because the joint between the link connecting two cells and the terminal connected to a set of plates are poor or loose.

Connect the 30-volt range of the voltmeter as shown in Fig. 566. Close the starting switch. No indication will be obtained if the joint is good, but if the joint is defective there will be an indication. Try all joints in this manner.

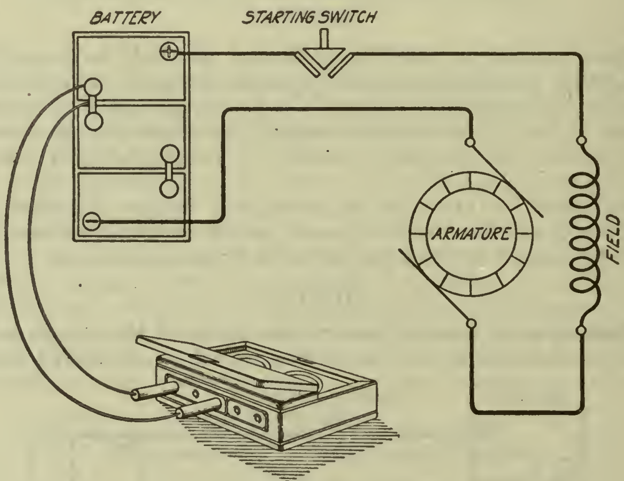


Fig. 566.

JOB 167.

Short Circuit in Motor.—If, when the instrument is connected as in Fig. 567, an indication is obtained which is much less than the battery voltage, there is a short circuit in the motor; or if the car has a grounded system there may be a ground in some part which should be insulated. When these conditions are indicated, the field should be disconnected from the armature and the following test made:

Connect a dry cell and either the Weston 6-10 Register or a six-volt twenty-candle-power headlight bulb in series with the field coils. Connect the three-volt range of the voltmeter across one of the field sections. Note the reading. If zero, the field section is probably short circuited. Repeat on the other sections. Fig. 567.

Note.—To secure the best results from this test an instrument having a range of about 100-milli-volts should be used. The Weston Model 280 Garage

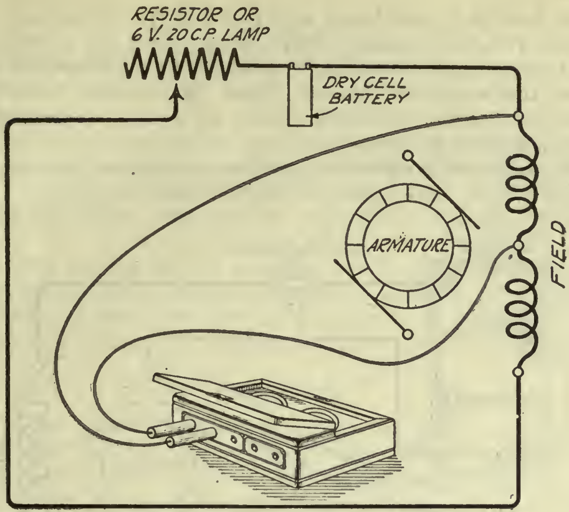


Fig. 567.

Type Volt-Ammeter is particularly adaptable for this purpose. Refer to Fig. 578.

If the field is found to be in good condition the armature should be tested for short circuited coils. This cannot be done with the model 441 Fault Finder. The test described is as made with the model 280 Garage type Volt-Ammeter.

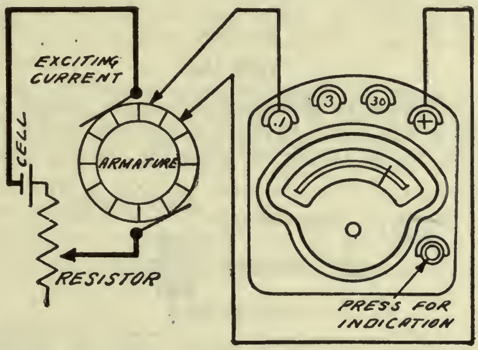


Fig. 568.

Connect as shown in Fig. 568. Using the 100-milli-volt range, measure between adjacent segments of the commutator. A short circuited coil will be indicated when the instrument reading is zero or very near to zero as compared to the readings on good coils.

The contact at the segments must be good, otherwise the results will not be reliable.

JOB 168.

Short Circuited Wiring to Starting Motor.—If the system is a two-wire, it may be possible for the insulation to become rubbed and a short circuit to result. To test for this, disconnect the wires from the starting motor, but be

careful not to have the ends touch any metal parts of the car. Measure the battery voltage with the starting switch open, using the 30-volt range of the instrument. Connect the instrument cables to the wires which have been removed from the motor terminals. Close the starting switch. A reading equal to the battery voltage shows the wires are good. Zero reading, or a very small reading, indicates a short circuit.

Note.—On one-wire grounded systems a ground on the one wire acts the same as a short circuit. See under wiring test, Job 173.

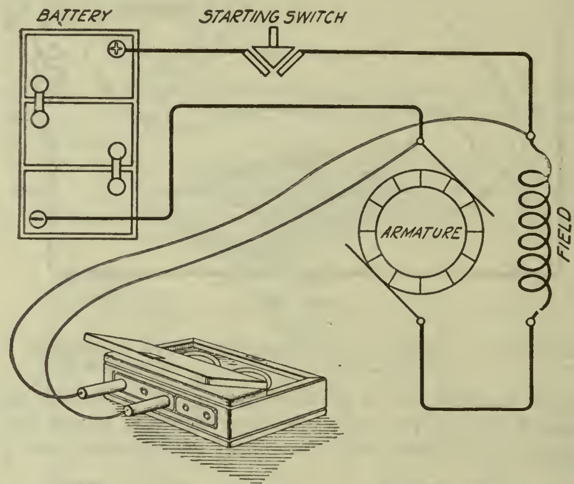


Fig. 569.

JOB 169.

Open Circuit in Wiring to Motor.—Connect the 30-volt range to the motor terminals as shown in Fig. 569. If there is an open circuit in the wiring there will be no indication on the voltmeter when the starting switch is closed.

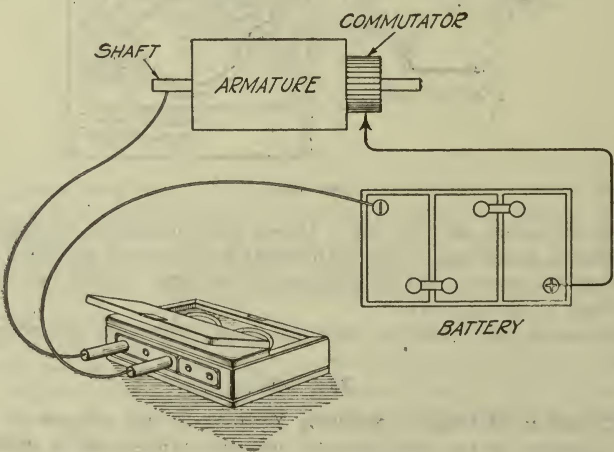


Fig. 570.

JOB 170.

Ground in the Motor Armature.—Remove the brushes from the commutator and disconnect the field. Use a six-volt battery and a thirty-volt range of the voltmeter.

Fig. 570 shows the connection to be made at the commutator and at the armature shaft. Any indication on the voltmeter denotes a ground. For the armature to be good the reading must be zero.

Grounded armatures are usually caused by damaged insulation of the armature coils.

In armatures having double windings. each of which is brought out to a separate commutator, each winding should be tested for grounds and then the connection made between the two armatures to determine if the insulation between them is defective. A reading indicates defective insulation.

JOB 171.

Ground in the Motor Field.—Disconnect the field so that its ends may be free and take care that they are not in contact with any metal of the car. Use the battery and voltmeter as in Job 170, making connection to an end of the field and the metal frame of the generator or motor. An indication on the voltmeter shows a grounded field. Zero reading shows a good field.

On single unit systems the generator and motor fields are wound on the same frame. Test each field separately for ground to the frame, then attach the test leads to the two fields to see if their insulation is defective. A reading indicates defective insulation.

JOB 172.

Grounded Brush Holders.—On two-wire circuits all brush holders are insulated from the metal parts of the motor or generator. In the grounded return systems one of the holders is in metallic connection with the frame of the motor or generator.

Only such brush holders need to be tested for ground as are intended to be insulated. Usually these are very readily detected by visual inspection.

In order to make the ground test on brush holders it is advisable to either remove the brushes or to put pieces of paper under them to insulate them from the armature. Then with the voltmeter and battery connected as in Job 170, Fig. 570, connect the test leads to the metal of the brush holder and the metal frame of the motor or generator. If the insulation is good the reading will be zero. Any reading other than zero indicates a ground.

JOB 173.

Grounded Wiring to Motor.—Disconnect the wires from any apparatus they may be attached to. Be careful that the ends are not in contact with metal parts of the car. Connect the voltmeter and a battery as shown in Fig. 570, Job 170. Connect one of the test cables to the end of the suspected wire and the other test cable to the frame of the car. Zero reading means good insulation. Any other reading denotes defective insulation. On two-wire circuits test each wire.

JOB 174.

To Determine if Generator is Generating.—Connect the 30-volt range of the instrument to the terminals of the generator and run the engine at its normal speed, Fig. 571. The voltmeter indication should build up to about seven volts on a normal six-volt system when the cut-out relay will close and the circuit through the battery be completed. If the voltmeter does not show any

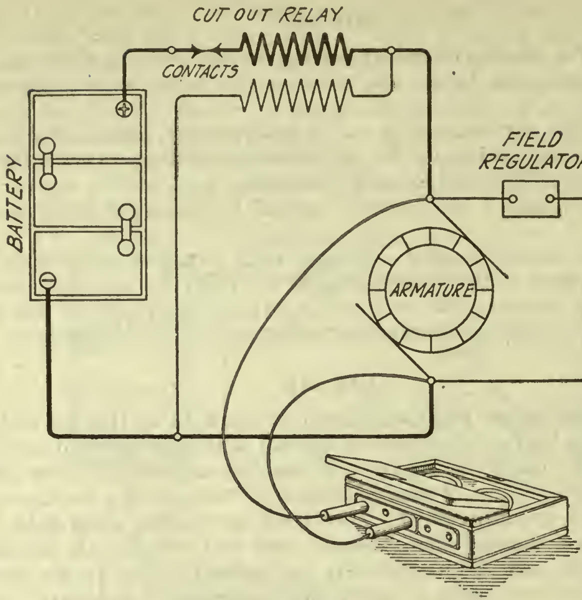


Fig. 571.

indication or one that is very nearly zero the field regulator is not working, Jobs 175 to 179, the armature may be open circuited, Job 181, the field may be open circuited, Job 180, or either may be short circuited, Jobs 182-183, or grounded, Job 184.

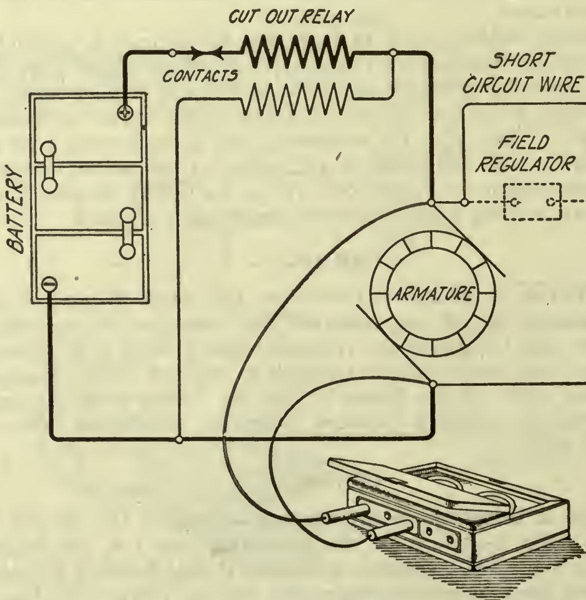


Fig. 572.

If the voltage goes much above seven volts, it is an indication that the cut-out relay is not operating properly.

JOB 175.

Defective External Field Regulator.—With the instrument connected to the 30-volt range as shown in Fig. 572, place a short circuiting wire around the field regulator so as to cut it out of the circuit. If the voltmeter indication goes up to the proper value the regulator is defective and should be repaired.

JOB 176.

Mercury Tube Regulator.—When the mercury tube type of regulator is used the mercury tube and plunger should be short circuited when making this test.

JOB 177.

Series Field Regulator.—When the regulation is accomplished by a series field connected to produce a bucking effect, this should be short circuited as shown in Fig. 573. The instrument is connected to the 30-volt range. If the series field is open, upon bridging it with the wire the voltage will immediately be indicated.

If the series field was short circuited within itself, the voltmeter would show an indication when the bridging wire was removed. The indication would increase above normal with increased speed of the engine.

Caution.—If the motor is also used for starting purposes be sure that the bridge wire is removed before trying to crank the engine with the starter.

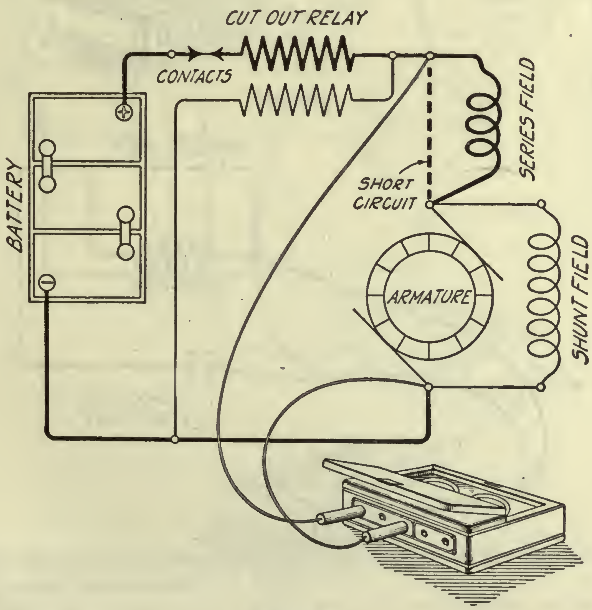


Fig. 573.

JOB 178.

Vibrating Regulator.—When the regulator is of the vibrating type, bridge the resistor R with a wire as in Fig. 574, and connect the instrument to the 30-volt range.

If an indication of about normal voltage value is obtained when the bridge wire is in place, either the resistor R is open circuited, or the contact blocks are not in good contact. It is well to clean the contacts carefully and make

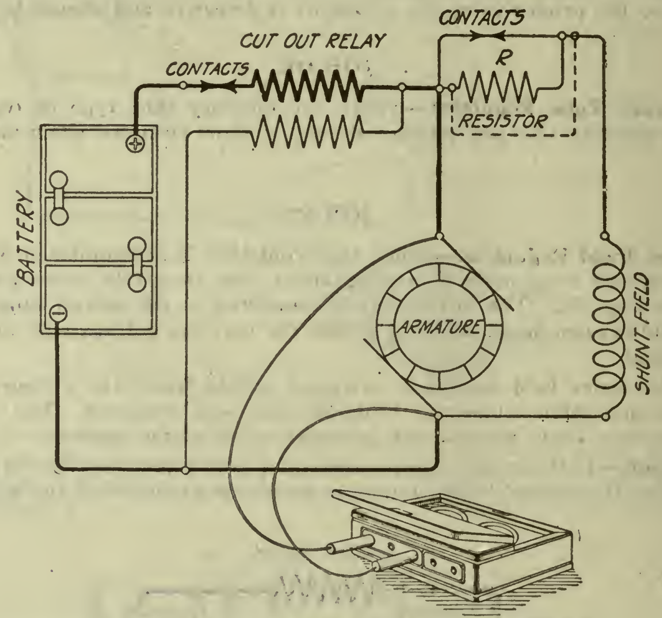


Fig. 574.

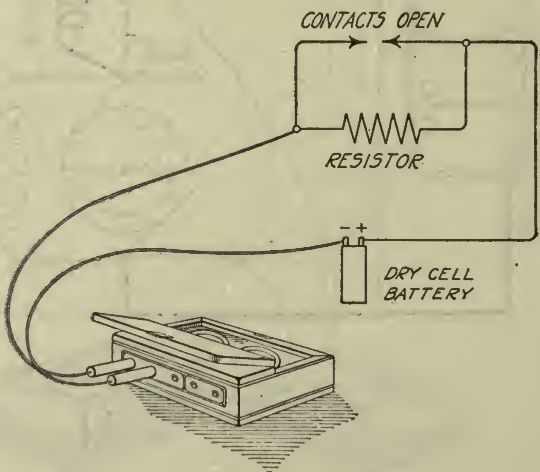


Fig. 575.

the test with the bridge wire removed. If the trouble has not been eliminated, try the resistor for open circuit. This is done with the engine stopped and a dry cell connected in series with the three-volt range of the voltmeter and the resistor as in Fig. 575. The contacts should be held open. If the resistor is not open circuited, an indication will be obtained. No indication means an open circuit. If the resistor were short circuited a voltage reading would be obtained when making test Job 174, but the voltage would increase above normal with increase in engine speed.

JOB 179.

Third Brush Regulation.—Failure of the generator with this type of regulation may be caused by the brush not bearing on the commutator. An incorrect generated voltage would be due to the third brush being out of place. This can be corrected by shifting the brush until the proper voltage is obtained.

JOB 180.

Open Circuit in the Shunt Field of Generator.—Do not run the engine. Disconnect the field from the regulator and complete the circuit through the 30-volt range of the voltmeter as shown in Fig. 576. If the field is open circuited no indication will be obtained.

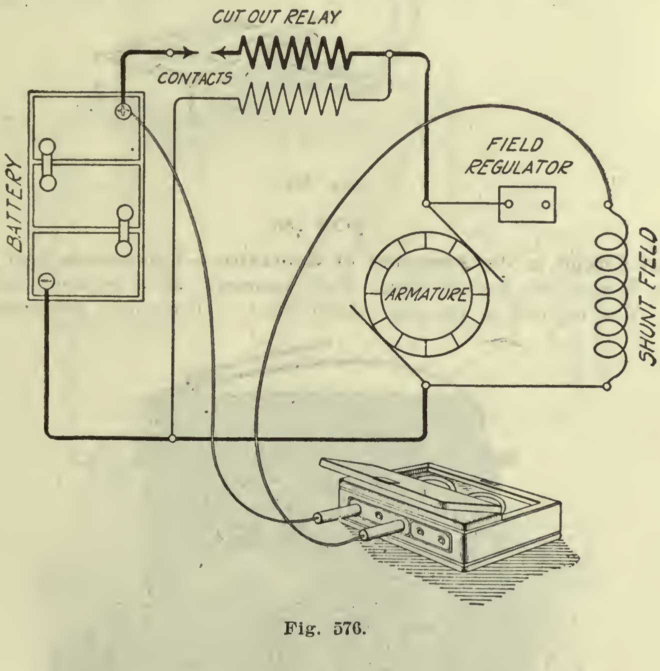


Fig. 576.

JOB 181.

Open Circuit in the Armature of Generator.—Apply the latter part of Job **164** for locating open armature coils.

Examine the brushes for contact and the connections to the brush holders.

JOB 182.

Shunt Field of Generator is Short Circuited.—Disconnect the field from the rest of the machine; connect the three-volt range of the voltmeter across the ends of the field. Then connect a dry cell across the field. If a short of any considerable magnitude exists the reading of the instrument will be zero or very nearly zero. If the field is not short circuited the indication will be somewhat near that for the voltage of the cell. It will be a little lower but probably over one volt for a good dry cell. (Fig. 577.)

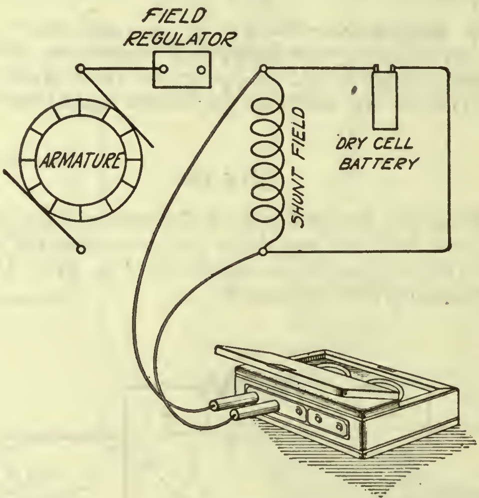


Fig. 577.

JOB 183.

Short Circuit in the Armature of Generator.—This test is best performed with the Model 280 Garage Type Volt-Ammeter, as a 100-milli-volt range is needed. The method to pursue is as follows: Disconnect the armature from

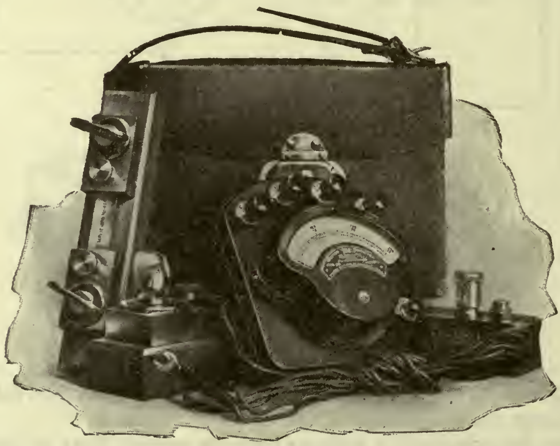


Fig. 578. Weston Model 280 Garage Type Volt-Ammeter.

the rest of the machine and try for open circuited coils as in the latter part of Job 164.

Then with a cell or battery connected in series with a suitable resistor, such as the Weston Special 6-10, manufactured by the Ward Leonard Electric Co., of Bronxville, N. Y., introduce a small current into the armature through the brushes. Using the 100-milli-volt range of the instrument, test between adjacent segments until the entire armature has been gone over. Short circuited coils will be denoted by a zero reading or by a reading very much less than that obtained on a coil which is apparently good. (See Fig. 568.)

JOB 184.

Grounded Armature or Field, or Brush Holders on Generator.—Proceed as directed under Jobs 170, 171 and 172.

JOB 185.

Short Circuit on Lines Between Generator and Battery.—Connect the ammeter as shown in Fig. 579 on the generator side of the cut-out relay. Run the engine at normal speed and note the reading of the ammeter.

Then change the position of the ammeter so that it is on the battery side of the cut-out relay as shown in Fig. 580. The reading of the ammeter should be practically the same as before. If any large difference exists it is due to a short circuit in the lines between the battery and the generator.

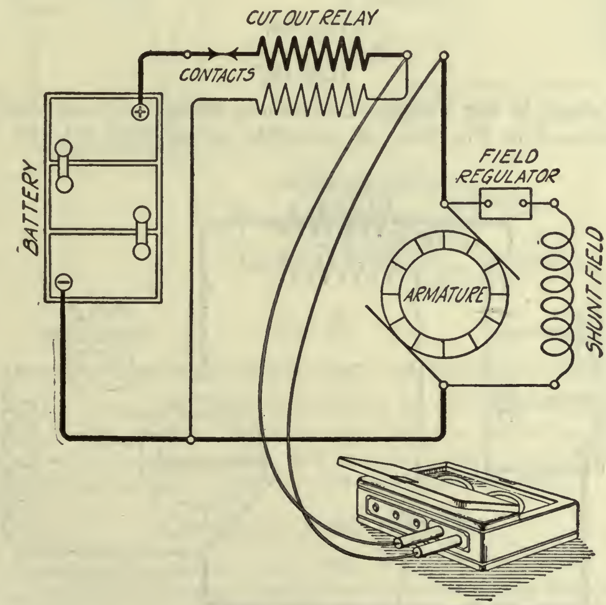


Fig. 579.

JOB 186.

General Tests for Relay Trouble.—Connect as in Job 174, Fig. 571. If the relay does not operate, the reading of the voltmeter will go above seven volts for a normal six-volt system. This may be due to an open circuit in either the series or the voltage coils of the relay.

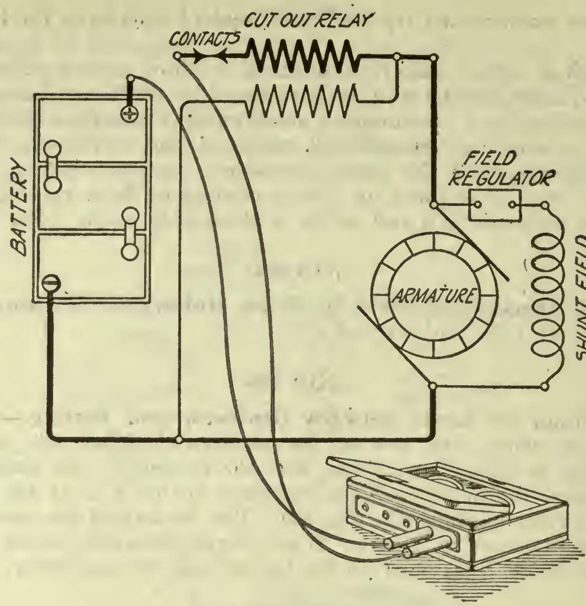


Fig. 580.

JOB 187.

Open Circuit in the Voltage Coil of the Relay.—Connect the 441 instrument as indicated in Fig. 581. If a reading is obtained the coil is not open

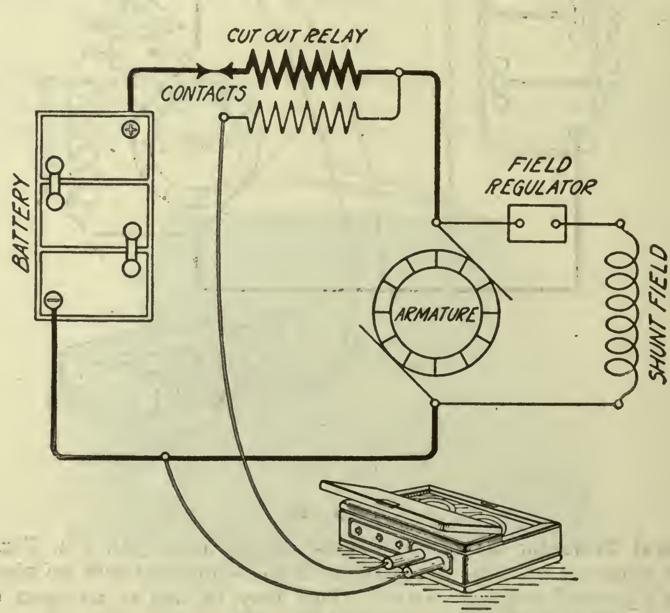


Fig. 581.

circuited. If no indication is given, move the test lead to the other end of the winding. If a reading is now obtained the coil is open circuited.

JOB 188.

Open Circuit in the Series Coil of the Relay.—Connect the instrument as in Fig. 582. If an indication is obtained the battery connections, wiring and generator circuits are likely in good condition.

Next move the test lead to the other contact point so as to include the series winding of the relay in the circuit being tested. If the winding is in good condition, the reading should be approximately equal to that in the first test. If no reading is obtained the coil or winding is open circuited.

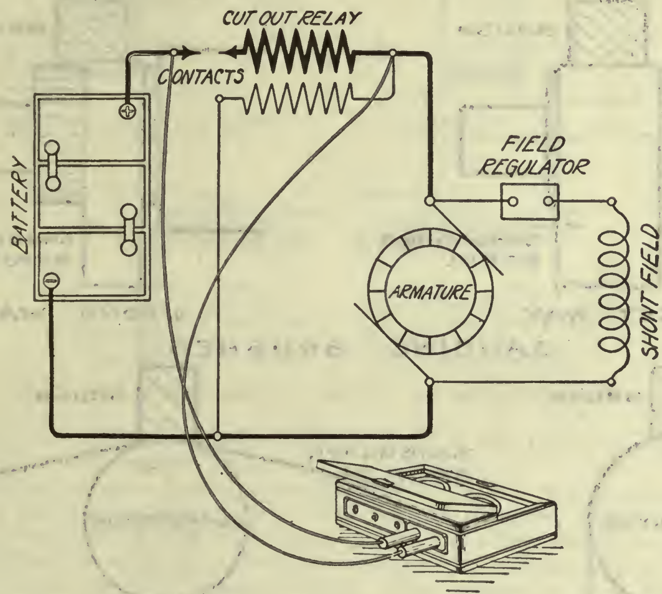


Fig. 582.

JOB 189. FITTING BRUSHES AND SANDING COMMUTATOR.

A commutator which is in good condition shows clean and bright although it may be of a purplish color. To clean, use kerosene on a rag and polish with a dry cloth. When a commutator has become roughened for any reason, it should be sandpapered with either 0 or 00 sandpaper or cloth.

SANDING COMMUTATOR.

1. Cut a strip of sandpaper the width of the commutator.
2. Pass this paper through under the brushes with the generator or motor in position on the engine. It is necessary in this work to remove only the inspection cover.
3. Keeping the ends of the sandpaper close together as indicated in Fig. 583, work the paper back and forth until the commutator is bright and smooth. Turn the commutator occasionally as the work progresses in order that all sides may receive the same treatment.
4. Polish the commutator with a rag and kerosene.

SANDING BRUSHES.

1. This operation is similar to the above in that the sandpaper is the width of the commutator and the machine is not lifted from the engine. The sand side of the paper however is placed to the brushes rather than against the commutator.

2. Allow the normal spring pressure to be exerted on the brushes as the paper is worked under them.

3. Continue the sanding until the brushes are a perfect fit on the commutator.

4. This remedy will properly care for noisy squeaky brushes as well as insure the proper fitting of new ones.

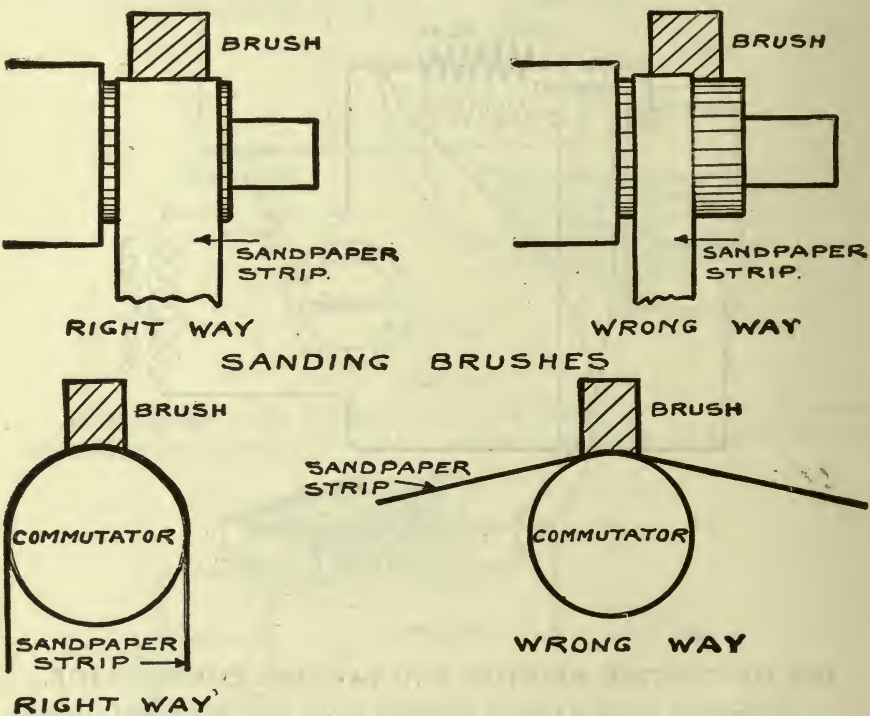


Fig. 583. Sanding Commutator and Brushes.

JOB 190. UNDERCUTTING MICA. Turning Down Commutators.

In service certain commutators will wear unevenly. The mica insulation between the commutator bars is harder than the copper bars and will not wear as fast. This is especially true in the case of generator brushes which, as a rule, are softer than the motor brushes. When this condition is evident the generator will not work properly, due to the fact that the mica holds the brushes away from the commutator. To correct this trouble proceed as follows.

A high or low bar in the commutator will require the same treatment as the high mica.

1. Remove the generator and dismantle.
2. Place the commutator in the lathe.

3. Set the lathe tool to take a light cut over the surface of the commutator. Remove just enough metal to allow the commutator to come out round.

4. Sand the commutator. Run the lathe at a high speed.

5. Place a tool in the lathe which is so ground that it will undercut the mica. This tool should be held in the toolpost and cut the mica as the carriage

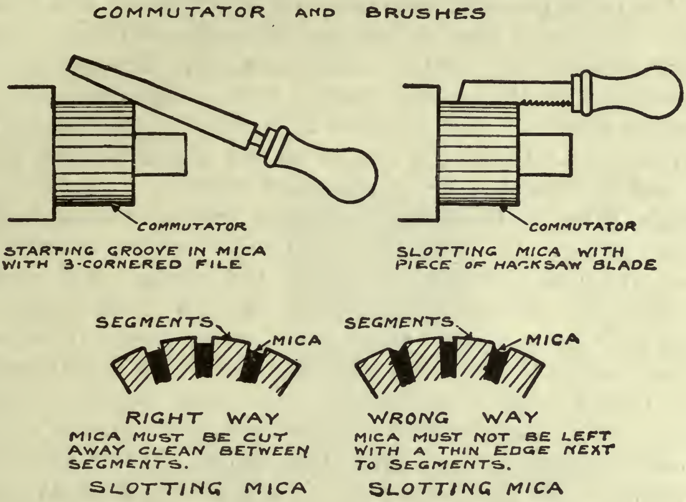


Fig. 584. Turning down commutator and undercutting Mica.

is moved forward, the armature being secured in one position. The proper depth for undercutting the mica is $\frac{1}{32}''$.

6. If the operator desires to do this work by hand it may be accomplished by using the method illustrated in Fig. 584. A hacksaw blade is carefully ground to have just a trifle more clearance than the thickness of the mica.

7. When the work of undercutting has been finished all burrs are removed from the edges of the commutator bars. The commutator then receives its final polishing before assembling the generator.

8. It is best to refit the brushes after turning down the commutator.

9. Keep a very careful watch over the commutator while the new brushes are wearing to a good seat. This will be within 200 miles' service.

CHAPTER 15

WIRING AND LIGHTING

As intimated in a previous chapter, the electrification of the automobile has made possible its most rapid development and refinement. Except in the case of some of the heavier commercial cars, practically all motor vehicles are lighted with electricity. The generating system together with the storage battery form a very necessary part of the lighting system. Two methods of wiring the lighting system are in common use. These are known as the single wire or grounded return, and the double wire or insulated return.

Single Wire or Grounded System.—This is meeting with more and more favor. It makes for simplicity in the construction of sockets and related parts as well as in the wiring. The single wire is run from the source of current to the light bulb socket, and is attached to it by means of a screw. Current enters from the wire, and after passing through the filament of the bulb is returned to the battery, through the frame of the car, lamp brackets and other metallic parts. The student will be able to pick out the single wire or grounded return systems illustrated in this chapter and elsewhere quite readily. The grounded point on any system is always indicated in the conventional manner.

The simplicity of the single wire for the lighting system commends itself to the average mechanic and owner as it is far easier to trace out troubles and circuits where it is used. In cases where it is used, any haphazard grounding of a single wire to the frame is almost certain to result in a short circuit, since the frame of the car might be likened to a live wire.

Either the positive or the negative terminal of the battery may be grounded.

Double Wire or Insulated Return.—In wiring the car lamps with this system twin wire is used. Twin wire has the two stranded lighting cables laid side by side in the one cable. Each cable is covered with rubber and carefully insulated from its mate. A glance at the wiring of a car will not always tell whether the cable used to carry the lighting current is the single or double wire style. Inspection of the bulb bases will indicate immediately which system is employed. Where the two-wire system is in use the sockets are equipped with two screws and connections for attaching the lighting cables. Due to the small size of the fixtures, the mechanic may experience some difficulty in making a workmanlike job of attaching the wires to the socket. A ground on one side of the lighting circuit running to any one lamp does not mean a shorted lamp in every case.

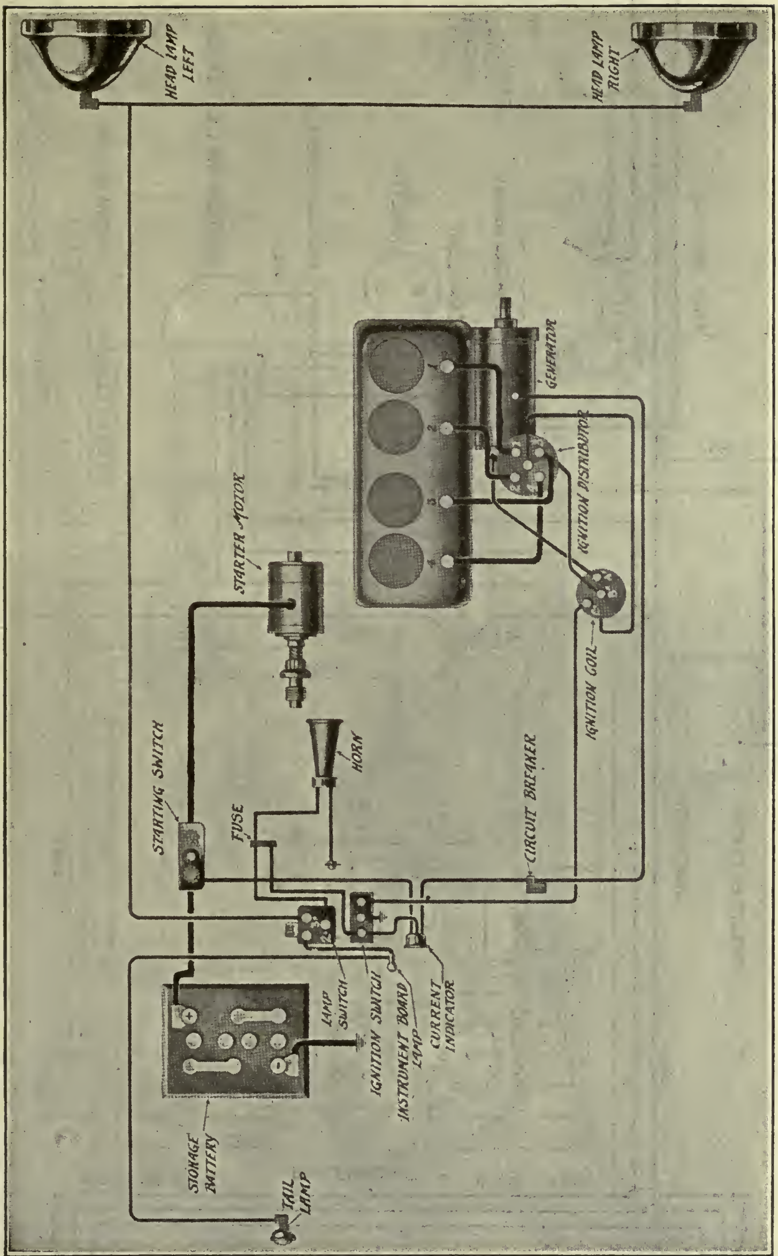


Fig. 585. Wiring Diagram. (Overland Four.)

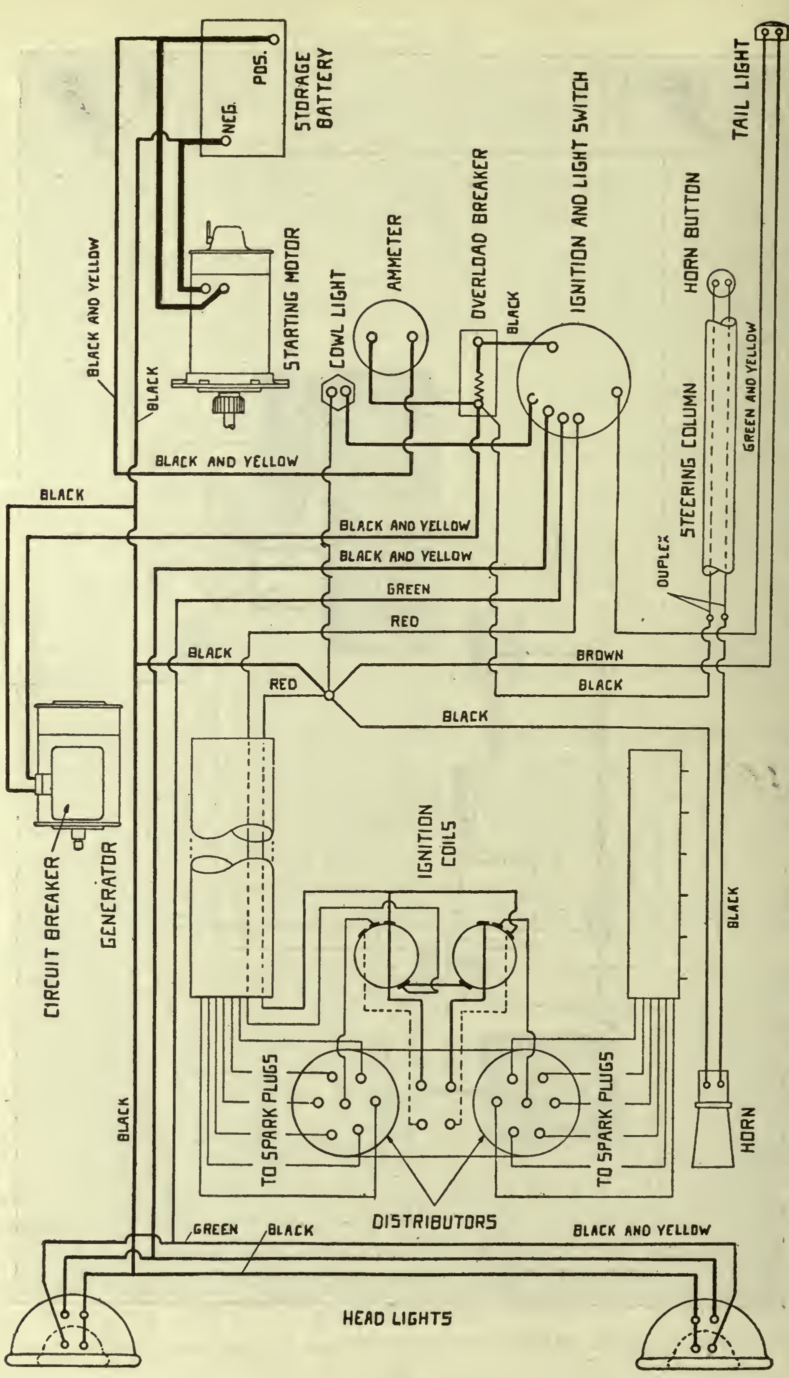


Fig. 586. Wiring Diagram of Leece-Neville Electric Lighting and Starting System, on Haynes Light Twelve.

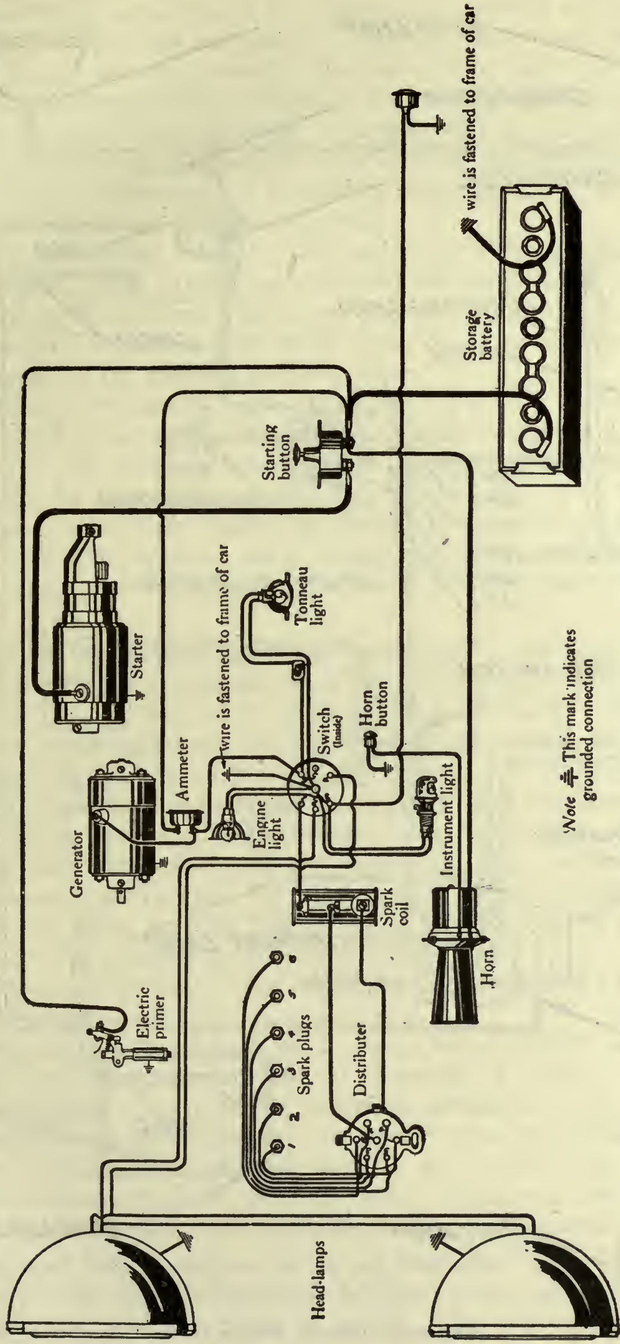


Fig. 587. Wiring Diagram National Sextet.

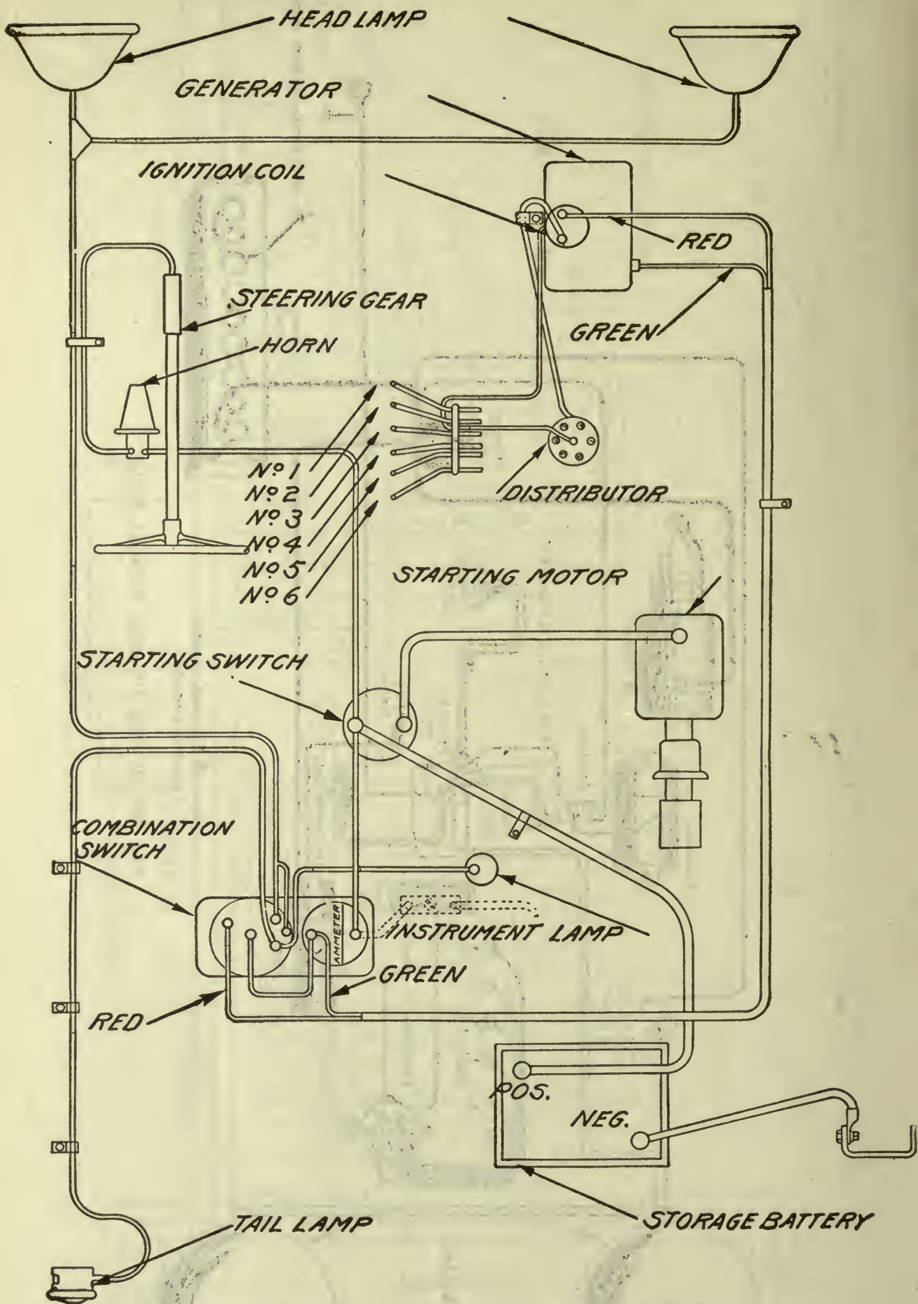


Fig. 588. Oakland Wiring Diagram.

It may, however, lead to trouble hard to locate, especially if similar grounds develop elsewhere in the lighting or ignition circuits.

Wiring.—Since all automobile electric systems are of the low voltage type, it is very essential that all wiring be of sufficient size to carry the current readily, and that all splices in the wiring or cables be properly made and soldered. A connection a bit loose is very likely to offer so much resistance that current will not flow. Wherever splices are made the job should be most carefully taped to prevent the development of a short circuit.

Where wires run close to the engine, or through points where the liability of heat, grease, or moisture affecting them is apparent, they are properly protected by loom. Loom may be of the fabricated rubber construction, or of the fiber type, or as in the case of more recent usage, of the flexible metallic type.

Lighting Switches.—There are many types of lighting switches on the market. In some instances the lighting switch is used in connection with the ignition switch. The switch may have a separate push button for each light or set of lights, or it may be so constructed and wired to give only those combinations for which there is most need. These combinations are: Headlights full, with dash and tail lights burning, and head lights dim, with tail and dash lights burning.

Head Lights.—Head lights are measured by the diameter of the lens or the distance across the front of the reflector. They will vary from 8″ to 10″. A bulb of from 15 to 30 candle power is set at the point of focus as explained in a later paragraph, and in this way, due to the highly polished surface of the reflector, is made to throw a beam of light of thousands of candle power onto the roadway. Where no side lights are used the headlight will have either one or two bulbs. If two bulbs are used the upper one is a small one of low candle power and is used for city driving or where dimmers are needed. The large or high candle power bulbs are used for country driving, or where a strong light is needed.

Where side lights are used they take the place of the small bulbs in the headlight.

Where only a large bulb is in use in the headlight and no side lights are provided, two means of dimming are used. The most common of these is to have the switch so arranged as to cut in a bit of resistance wire thus reducing the amount of current flowing to the headlight bulbs. The other method is to so wire the lights and switch as to throw the two bulbs in series. This will dim them quite effectually, but the same candle power bulbs must be used at all times.

Dash and Tail Lamps.—These are frequently so wired and connected that one bulb burning out will put both out of commission. In other words they are wired in series. If a 6–8 volt system is in

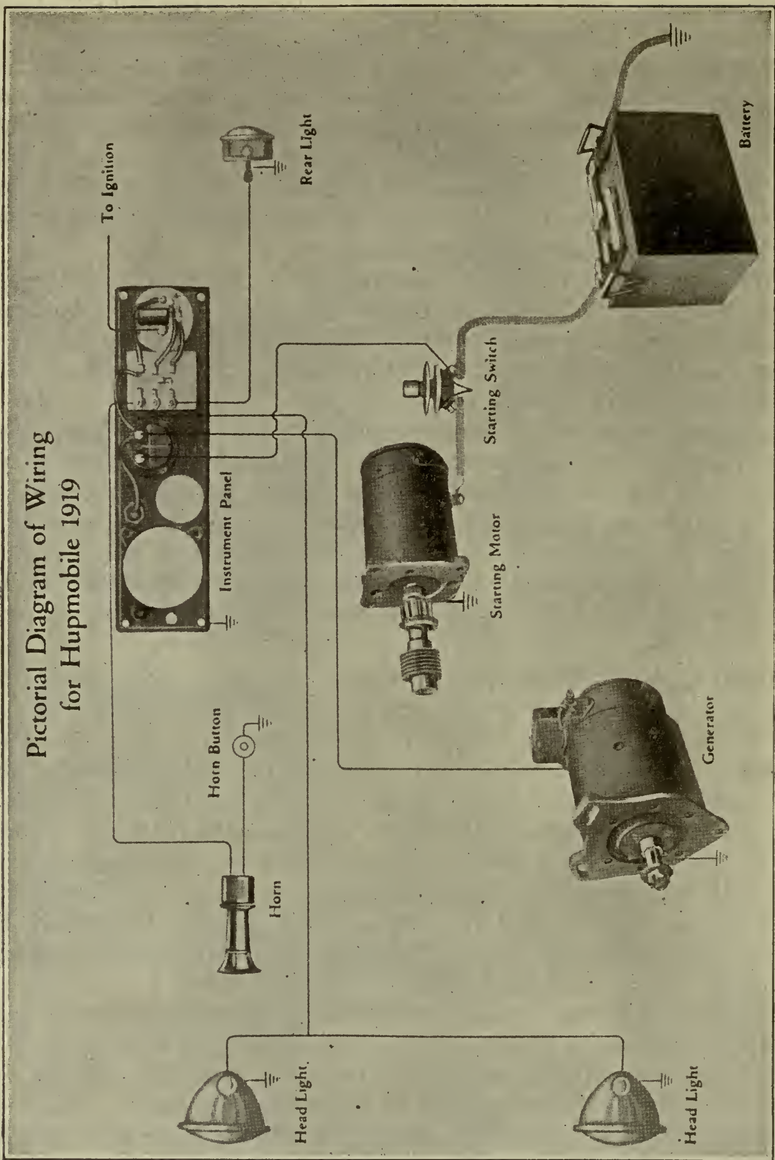


Fig. 589. Remy Hupmobile Electrical Equipment and Diagram of Wiring.

use the bulbs for tail and dash lights in series would be 3–4 volt. In most cases two-candle power bulbs are used. Where this system is in use the driver is aware instantly any trouble develops with the tail light. This may save him much embarrassment in night driving to say nothing of the added safety assured the motor car.

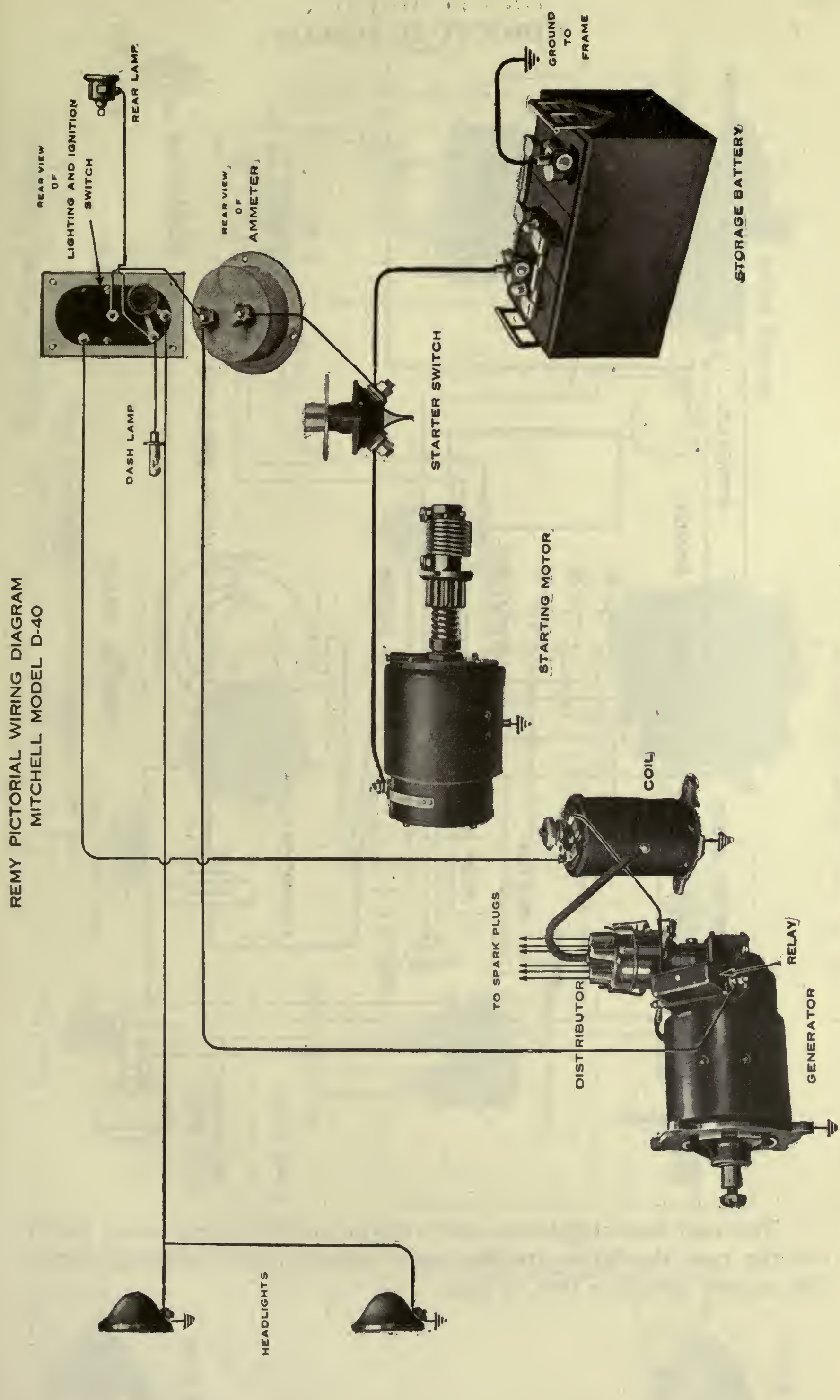


Fig. 590. Remy Electrical Equipment for Mitchell Car.

CIRCUIT DIAGRAM

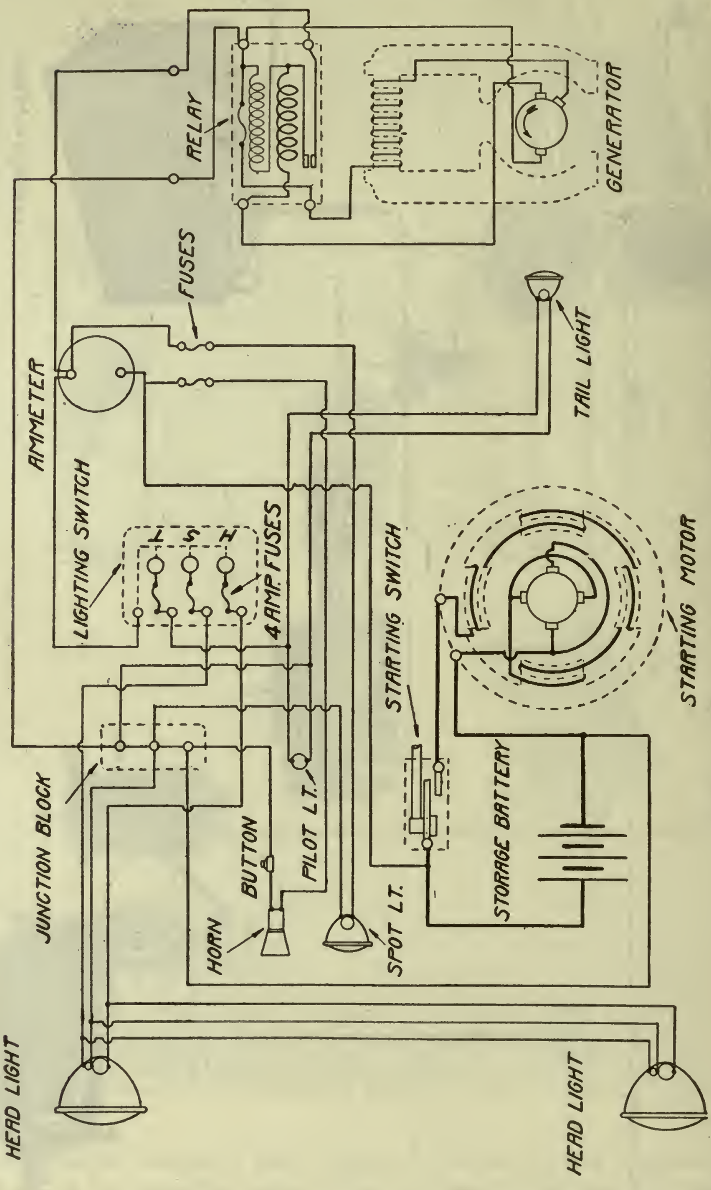


Fig. 591. Technical Wiring Diagram, Remy Stutz.

Tail and dash lights are not always in series, and when this is not the case the bulbs are the same voltage as the electric system. The candle power is two to four.

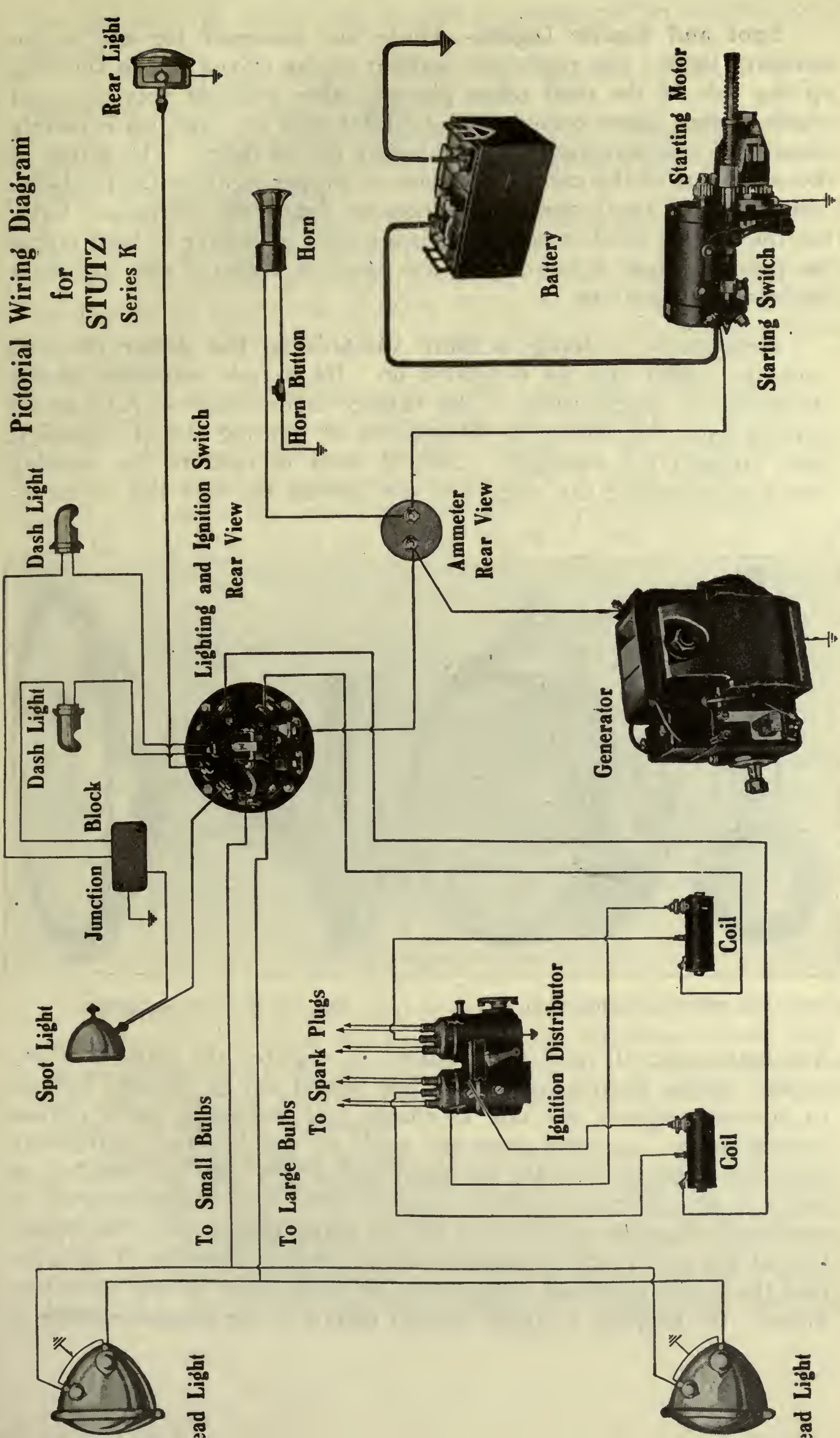


Fig. 592. Remy Electrical Equipment for Stutz Car.

Spot and Search Lights.—These are designed for use as an auxiliary light. For roads not familiar to the driver and in showing up the side of the road when passing other vehicles they are well worth while. Some communities prohibit their use, but this is merely because of the unrestrained and abusive use of them. The safety of the occupants of the car is dependent on proper light on the roadway. The safety of the pedestrian is likewise dependent on proper light, but the glaring head or spot light is a source of danger to both unless the pencil of light is kept below the point of vision of the approaching car or pedestrian.

Ammeters.—Nothing is more valuable to the driver than an ammeter which may be depended on. Its proper indication of the charging and discharging of the battery is invaluable. All current passing from the battery to the ignition or lighting circuit must first pass through the ammeter. Current used to operate the starting motor in cranking the engine is not passed through the ammeter.

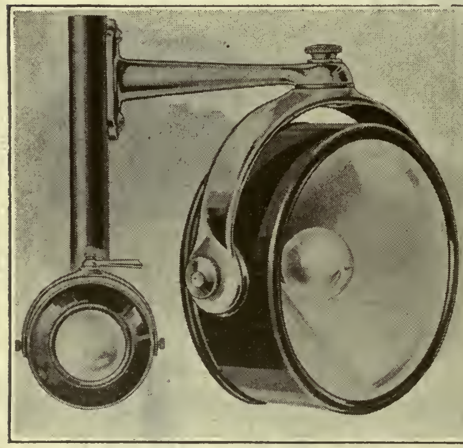


Fig. 593. Stewart Spotlight.

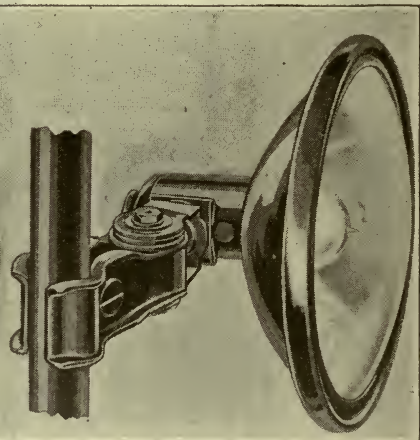


Fig. 594. Stewart Searchlight.

An instrument of sufficient capacity to register the output of the battery during the cranking operation would not be delicate enough to properly register the rate of charge and discharge under normal circumstances. A good ammeter such as the Weston instrument, with which many cars are equipped and which may be installed on any not so equipped, is shown in Fig. 609. This instrument or its equal will show the operator of the car many things about the operation of his car which he needs to have exact knowledge of in order that the entire electrical system may be maintained in first class condition. By keeping a careful mental record of the proper reading of

the ammeter the driver will be able to recognize the following conditions:

1. The proper discharge when the ignition switch is on and when the engine is idle or running.
2. The proper charge rate in the daytime when the lights are off and the engine driving the car at a fifteen mile rate, above or below that average point.
3. The proper charge rate at night time when the lights are being used and speeds are similar.
4. The proper discharge with the engine not running, when headlights are bright and all other lights are on. The proper amount of increase in discharge when a spot light is added to the regular lamp load.
5. The proper discharge when the headlights are dimmed.
6. The proper amount of current for operating the horn.
7. Whether there is a variable contact in the electrical circuit.
8. Whether the generator brushes are in good order.
9. Whether the generator regulator is operating properly.
10. Whether there are certain types of leaks or short circuits in the electrical system when the car is standing idle.

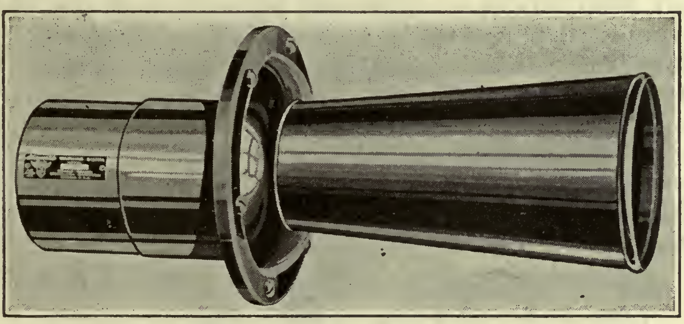


Fig. 595. Stewart Electric Horn.

Voltmeter.—The voltmeter is not a part of the regular equipment. Its purpose is to show the pressure of the electrical circuit just as an air gauge shows the pressure in a tire or in a compressed air tank. Its use in making electrical tests is explained elsewhere. Fig. 610 shows the Weston Voltmeter.

Junction and Fuse Boxes.—In certain systems as employed by the car manufacturers all the wires forming the lighting and ignition circuits (low tension) are brought together at a central point in a fuse box, or junction box. At this point the proper weight of fuse is placed in circuit to protect that part of the system to which the wires lead, from injury due to too heavy a discharge of current. Not

all cars are so equipped and where not so cared for the system is frequently protected by one central fuse.

Bulbs and Sockets.—The bayonet base has come to be adopted as standard for the miniature bulbs used in automotive equipment. The miniature bulb with the screw base is not used to any extent for this type of work. Its use was discontinued because of the liability of the vibration causing the bulb to work out and break contact. The single contact bayonet base is proving the most popular due to greater simplicity of the sockets and the entire wiring system.

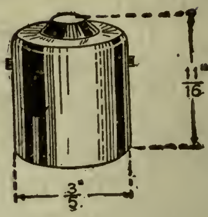
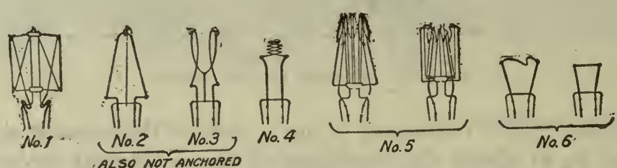


Fig. 596. Single Contact Bayonet Base, Standard for automobile lighting.

The Proper Lamp for the Service.*—In the design of miniature Mazda lamps, it is the aim to provide a product which will operate at an economic balance between efficiency on the one hand, and lamp life on the other. This means that the question of operating voltage must receive close attention, for both factors are very sensitive to voltage conditions; the higher the voltage at which a given lamp is operated, the higher the efficiency of the lamp and the shorter its life. For the best performance, incandescent lamps must be supplied with constant voltage (in some cases, constant current) of the proper value. Miniature lamp service is, in general, however, such that the lamps must be designed to give the best possible operation over wide ranges of voltage. The characteristics of the energy supply—whether storage cells, dry cells, battery generator systems, magneto, or central station service—must be carefully taken into account. Lamps must be designed to operate efficiently and to give satisfactory life; they must not burn out in an unreasonably short time at high voltage and they must give fair illumination during the time they are operating at low voltage.



Filament Forms Used in Miniature MAZDA Lamps

Fig. 597.

Design of Lamps for Use with Storage Batteries.—In the design of lamps for use with storage cells, it is necessary to take into consideration the voltage variations which occur throughout the entire time of discharge. For example, a lead-type liquid-electrolyte storage cell, the type at present most commonly used with miniature lamps,

*Courtesy, National Lamp Works.

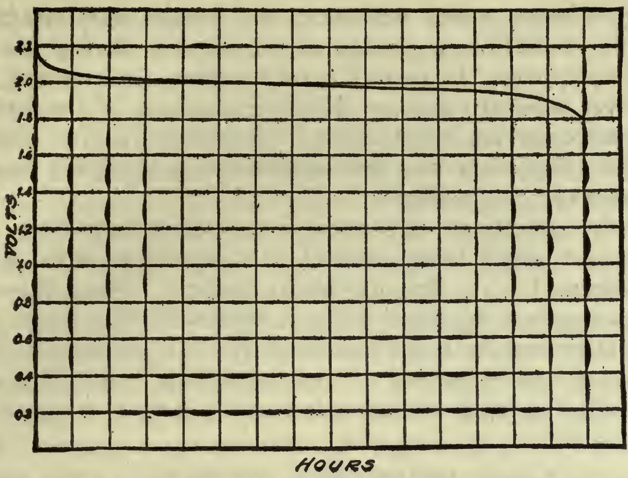


Fig. 598A. Storage Battery Discharge Curve.

has an initial open-circuit voltage of about 2.2 volts per cell. During discharge, this voltage rapidly drops to slightly above two volts, from which point the decrease in voltage is very slow and uniform for a considerable period, depending upon the rate of discharge and the capacity of the battery. As the cell approaches exhaustion, the voltage again decreases very rapidly. Due to destructive chemical action which may take place within the cell near exhaustion, it is not considered good practice to allow the voltage to drop below about 1.8 volts, and this value represents, therefore, the lowest working voltage of the cell. The curve of Fig. 598A is typical of the continuous discharge characteristics of lead-type liquid-electrolyte cells in general. The rate of discharge and capacity of the cell affect, of course, the voltage which the cell maintains.

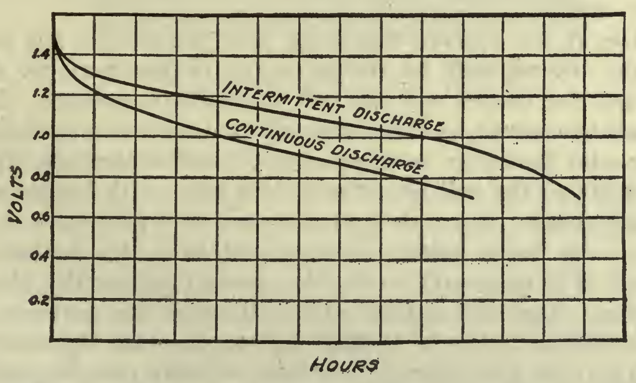


Fig. 598B. Typical continuous and intermittent average discharge voltage curves for No. 6 dry cells discharging through miniature mazda lamp.

Another factor which influences the design of miniature Mazda lamps is the condition of charge of the battery during the time the lamps are operating. In certain hand lanterns, for instance, the lamp operates over several complete discharge periods of the battery. In electric vehicle service, the battery is seldom allowed to discharge to a point near exhaustion, and the lamps must be designed therefore for a higher average cell voltage.

With the conditions of service known, it is possible to calculate the voltage for which lamps should be designed in order to give the desired average life on that particular battery. Since these calculations are somewhat involved and are influenced to a large extent by physical limitations in lamp manufacture, it is requested that those engaged in the development of new apparatus employing miniature lamps consult the lamp manufacturer at as early a stage of development as possible.

Design of Lamps for Use with Dry Cells.—In the case of dry cells the individual voltage of the cells will vary widely, depending upon the composition of the cell. On continuous discharge, where a cell does not get a chance to recuperate, the voltage will show a continuous drop from the initial voltage. When the cell is on intermittent discharge, the discharge curve is composed of a succession of periodic discharge curves, each succeeding curve having lower maximum, minimum, and average voltage values. Due to the recuperative action, the average voltage of a cell in intermittent service may be considerably higher throughout the useful life of the cell than will that of one used for continuous service. Fig. 598B shows typical intermittent and continuous discharge curves obtained from dry cells discharging through Mazda lamps. A period of at least two hours was allowed between the periodic discharges for recuperation. Experiments show that in the ordinary commercial cell after two hours' recuperation, further voltage rise and capacity increase are negligibly small.

In general, for a given discharge rate, the shorter the periods of service, the higher will be the averages of the periodic discharge voltages and the longer will the cell maintain its voltage. However, when a cell is allowed to stand unused for long periods, the averages of the periodic discharge voltages may fall off even more rapidly and the useful life of the cell be actually less than with longer discharge periods and shorter intervals between such periods.

Before the lamp voltage best suited to a dry battery can be determined, it is necessary to decide to what degree the illumination may decrease from the normal and still serve the purpose at hand, to express this in terms of voltage and to consider the usefulness of the battery at an end when the battery voltage has dropped permanently below this value. The procedure is as follows: The voltage

curve of the particular type of battery in question is taken under certain conditions of load from initial voltage to the point where the voltage has dropped to 0.7 volt per cell in the case of dry cells of the standard No. 6 type or to 0.5 volt in that of flashlight cells. The voltage curve between these points, translated into terms of lamp life, forms the basis for the lamp design. The discard point of the battery is considered as that point in the discharge when the voltage has decreased to 60 per cent of the mean effective lamp voltage. This naturally varies considerably in different types of cells, one of the important factors being the cubical content. Lamps must be designed in a wide range of voltages to suit the different styles and capacities of dry cells in common use. The voltage ratings are, however, purely nominal and do not represent the actual design voltage. For example, at present, flashlight lamps for use on two-cell batteries have nominal ratings of 2.5, 2.7, and 2.9 volts depending upon the capacity of the battery with which they are to

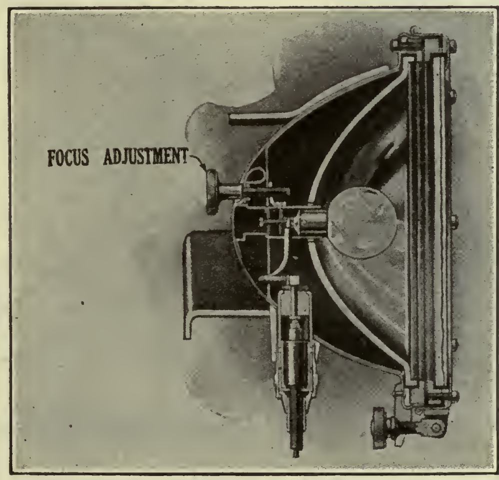


Fig. 599. Focus Adjustment on Headlamp for Standardized Military Truck Class B.

be used. Periodic tests on batteries are conducted to insure a lamp product suited to modern battery product.

Referring again to Fig. 598B it is seen that for all values of voltage higher than 0.7 volts, the average voltage curve on intermittent discharge lies above the continuous discharge curve. Hence, a greater proportion of the total energy of the cell may be utilized on intermittent service than on continuous service. Moreover, the variation of voltage throughout the greater portion of the life of the battery is between narrower limits and the candle-power of the lamp is more nearly constant.

Design of Lamps for Use with Battery—Generator Systems.—Lead storage batteries in combination wtih generator systems are a third type of energy source much used for miniature lamps, particularly in automobile and motor-boat service. There may be as much as 35 per cent difference between the voltages at which the lamps operate when the engine is idle and the battery is near exhaustion, and when the engine is running and the battery is in a state of saturation. It is necessary to design the lamps for such service to give fair illumination at a low voltage and to give satisfactory life performance despite the voltage variations above normal. Large numbers of tests conducted on a large number of the various makes of automobiles under widely different conditions of service have made pos-

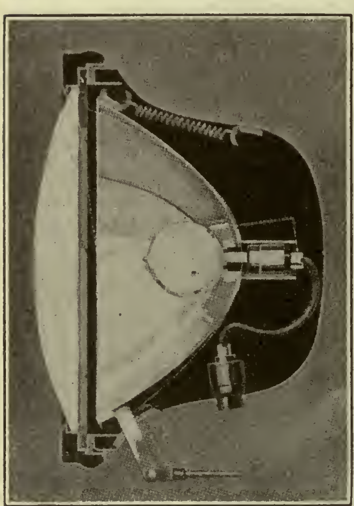


Fig. 600. Sectional View Cadillac Head Lamp.

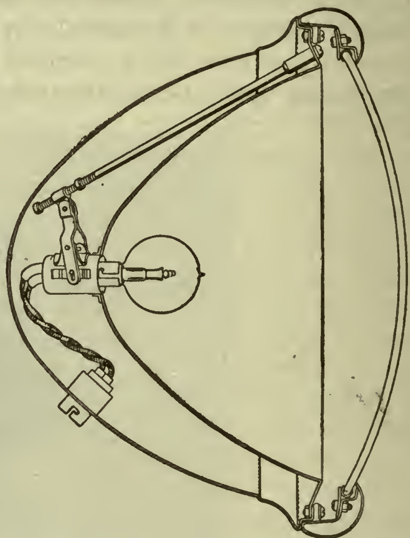


Fig. 601. Gray and Davis Focusing Device.

sible the design of lamps adapted to battery-generator systems where the average normal voltage fluctuation is between 6 and 8 volts, 12 and 16 volts, and 18 and 24 volts. Lamps for this service are rated 6–8 volts, 12–16 volts, and 18–24 volts, respectively.

Design of Lamps for Magneto Lighting Systems.—The straight magneto system of energy supply is about the most difficult system existing for which to design satisfactory lamps. The voltage varies in about direct proportion to the speed of the magneto. The magneto speed in turn, usually varies directly as the engine speed, with the result that the lamp is called upon to furnish illumination over an extremely wide range of voltage. In the design of lamps for magneto service, the aim is to provide a lamp which will supply sufficient illumination at the lower engine speeds yet which will not burn out

in an unreasonably short time when the engine is running at high speed. Lamps which meet these requirements will supply satisfactory lighting at the usual running speed.

Some Fundamentals of Light Projection.—A large proportion of all miniature Mazda lamps are designed for use in equipments which

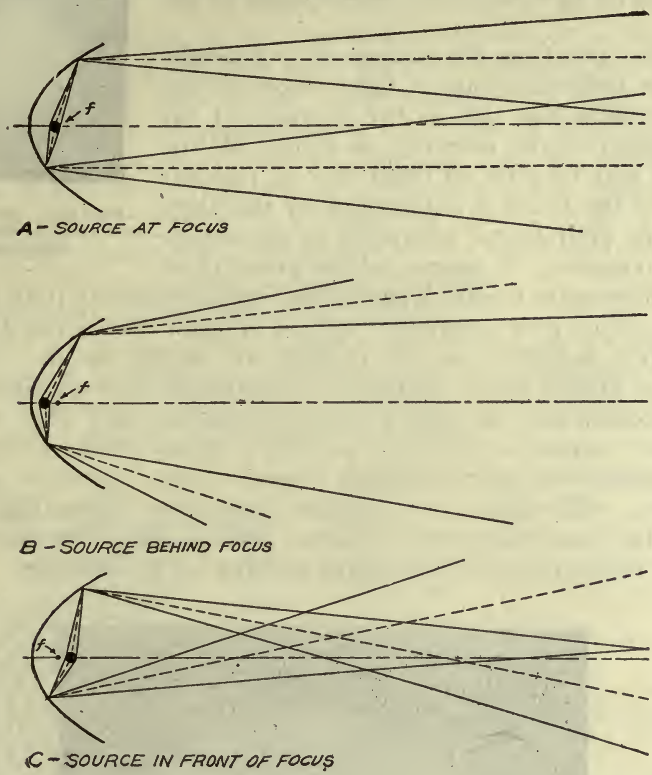


Fig. 602. Beam characteristics of Parabolic Reflector with light sources in three Positions.

project the light in relatively narrow beams. In flashlight service, the lamp is usually equipped with a reflector or lens system which, while directing the light in a beam, does not confine it closely; in headlight and spotlight service, the beam is confined to a considerably narrower angle. In practically all cases, the desired effect is secured through the use of a polished reflector of a contour which confines the light to the desired angle.

The narrowest beams of light are obtained with paraboloids, that is, with reflectors whose surface is formed by revolving a parabola about its axis. When a source is placed at the focus of a parabolic reflector, the light rays striking the reflecting surface are projected

forward in a beam, the central ray of which is parallel to the axis (See A, Fig. 602). When the source is placed behind the focus, the beams diverge as shown in B. When the source is in front of the focus, the beams converge, cross, and diverge as shown in C. Contrary to the idea sometimes advanced no light is lost by the crossing of the beams.

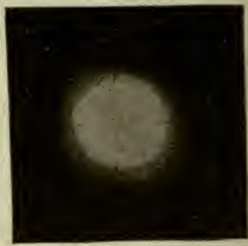


Fig. 603. Appearance of Spot from properly focused Headlights.

Every point on the surface of a parabolic projector reflects a cone of light whose spread depends upon the size of the source and the focal length of the reflector, as shown in Fig. 602. It will be seen, in other words, that the spread of the beam is determined by the angle which the light source intercepts at the surface of the reflector. A source which presents its largest dimension toward a part of the reflector remote from the focus will, therefore, give a narrower spread of beam than when it presents the largest dimension to the closest part of the surface. The filaments of Mazda lamps designed for headlight and spotlight service are condensed into as small a space as practical, and when set at the focus of a parabolic projector, provide a beam which is very highly concentrated. A position of the filament, either ahead of or behind the focus, will result in a broader beam; but if the filament lies behind the focal point, the reflecting surface will catch and reflect a slightly larger portion of the light emitted by the filament.

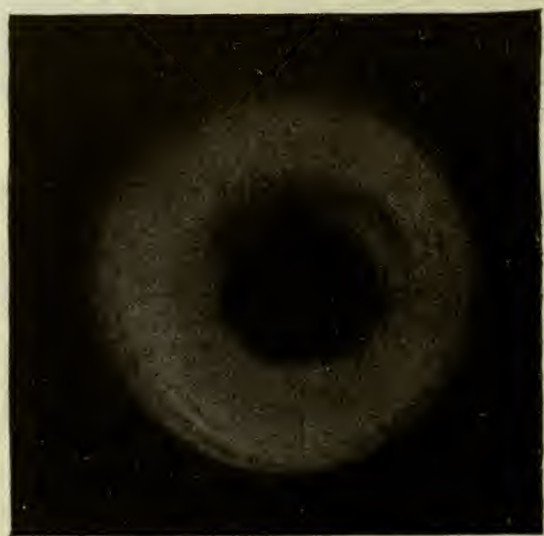


Fig. 604. Appearance of Spot from Headlights with light source too far ahead of or behind focal point.

The motorist should make a very careful study and adjustment of his headlights. The adjustment can best be accomplished by standing the car on a level roadway and projecting the headlight beams, without any glare-reducing device, upon a flat surface perpendicular to the axis of the beam, at a distance of not less than 25 feet. The lamps should then be adjusted in the reflector by means of adjusting screws or other devices now furnished on all good headlights, until the smallest spots of light obtainable are thrown on the distant surface. The lamps will then be at the focal points of the reflectors. The appearance of the spot of light projected by each headlight should in this case be approximately as shown in Fig. 603. If the lamp is too far ahead of or behind the focus, the spot should appear about as in Fig. 604. With the lamp in focus, careful measurements should be made to determine whether the centers of these spots of light are any higher than the centers of the headlights themselves. If they are, the headlights should be bent down until the centers of the beams come slightly below the horizontal.

There are three general types of glare-reducing devices for use on automobile headlights: One type operates by diffusing the light, another by refracting or reflecting the light rays; the third by cutting off the rays which would be projected upward.

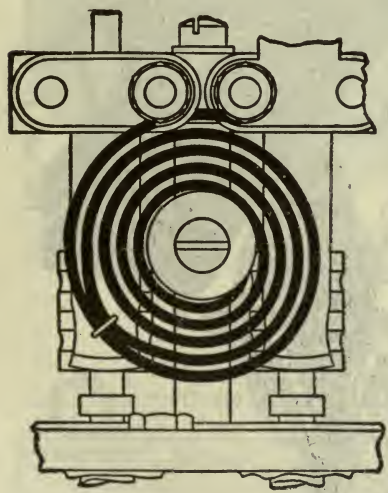


Fig. 605. Varying the Dimming of Headlights. (Hudson.) By tying two of the coils together the amount of resistance wire in circuit on dimmer is lessened and lamps burn brighter.

JOB 191. SPLICING LIGHTING CABLES.

It is frequently necessary to splice a wire in order to lengthen it. Another splice is the one in which it is necessary to cut in on a circuit for a branch to some special instrument as the search or spot light.

1. In making the end splice the first step is to determine the length of end necessary to be exposed in order to splice.

2. With a sharp knife run a light cut around the wire at this point just cutting through the outer layer of cotton covering. To make this cut in a careless manner is certain to result in severing some of the fine strands.

3. Using the point of the knife, split the insulating material from the first cut made to the end of the cable. This operation requires care as the knife actually cuts down to the wire strands.

4. Open the cable at the end and pull out the strands of wire through the slit just made.

5. Use the knife to finish the first cut made. This is easily accomplished since the cable strands are kept twisted together and may thus be pulled away from the insulation while same is being trimmed.

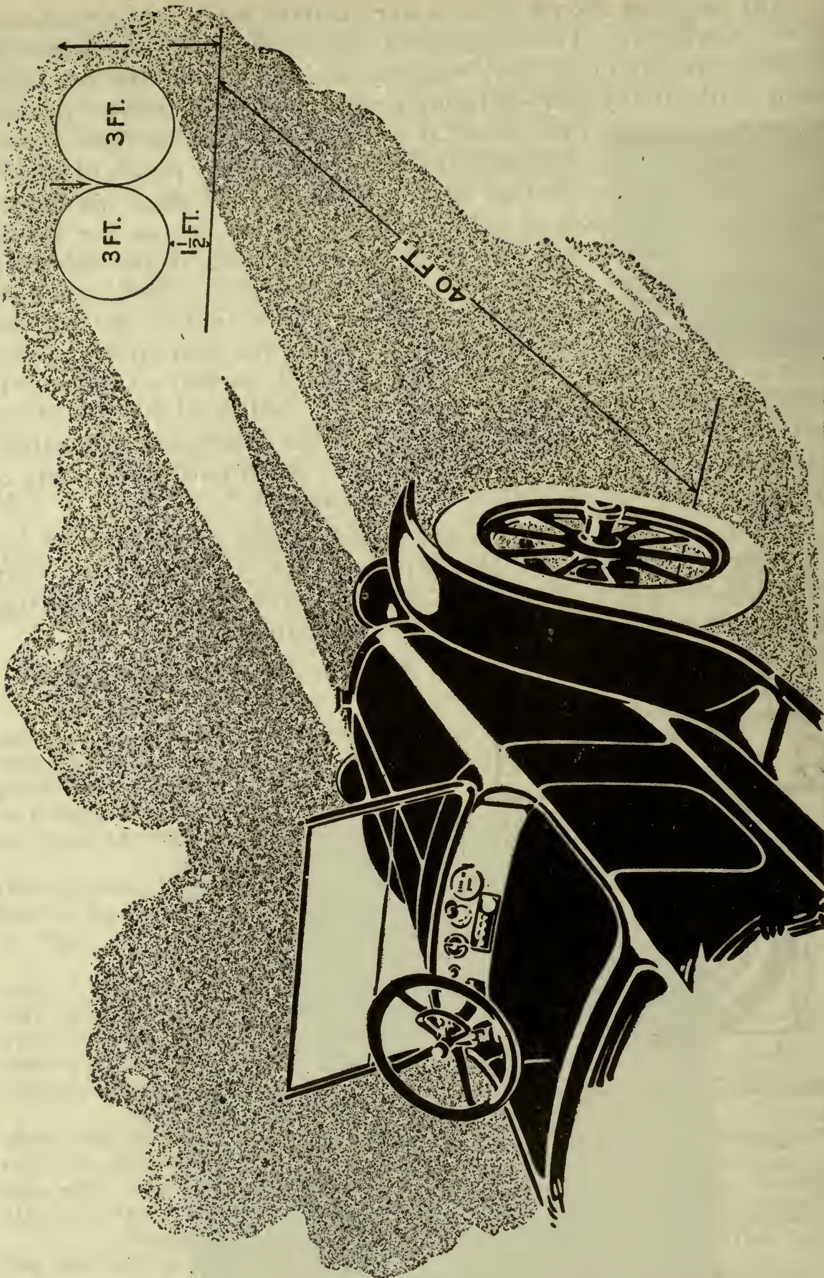


Fig. 606. Focusing Headlamps. (Courtesy Hudson.)

6. With an end of each length of wire free of all insulation the two are twisted together in the form best suited for the work in hand.

7. Treat the splice with soldering paste and solder carefully. Make

certain that the solder runs into the strands and does not merely rest on the outer surfaces.

8. In making a splice where the end of the new piece of cable is joined onto the old cable, at some point other than the end, the first step is to remove the cable insulation at the point desired to tap in on the main circuit. Do this work most carefully in order that not one of the small strands is injured. Make the splice, solder and tape as suggested above.

JOB 192. SWEATING OR BURNING ON A TERMINAL.

It is frequently necessary to sweat or burn on a new terminal for some of the leads of the electric system. This work may be necessary in reference to the storage battery terminals or any of the numerous terminals such as are found about the ammeter, the generator, or the starter. Burning or sweating in this case means having the solder worked while in the liquid or melted state.

1. Select the new terminal with reference to the requirements of the job. Where the old is still in such condition as to permit of comparison, the new terminal should be matched to it.

Fig. 607. Reverse side of Weston Ammeter. Note terminals and binding posts.

2. Prepare the cable by removing as much of the insulation as may be necessary to permit the strands to enter the terminal properly.

3. Twist the strands together and tin them. To do this they must be clean. The soldering iron may be used to flow the solder onto the cable end; the end may be treated with soldering flux and dipped into a pot of melted solder, or the end may be tinned by the use of the lead burning or other light flame.

4. Next prepare the terminal by tinning the inside of it and running it full of melted solder.

5. Keep the terminal hot. The end of the cable previously tinned is heated and the two while hot are forced together. This will crowd out some of the solder in the terminal, but it is better to have too much solder than not enough.

6. When cool, the job should be cleaned and taped if necessary.

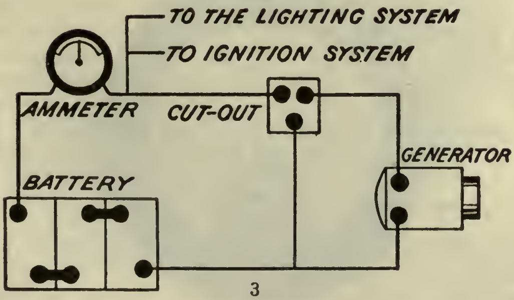


Fig. 608. Suggestive diagram for wiring an ammeter. (Weston.)

JOB 193. ATTACHING WIRES TO LAMP SOCKETS.

1. Remove the insulation for such a distance as is necessary to expose enough cable to enter into the socket.

2. Sweat the ends of the stranded cable together. (Job 192.)

3. Carefully insert the sweated ends of the cable into the small tubes mounted in the sockets. Make certain that the small set screw is backed out sufficiently to allow the cable end to enter. Use a small screw driver for this screw, otherwise the hard rubber socket may be broken.

4. When all is properly assembled, tighten the binding screw.

5. Never pull or jerk on the lamp wires as they are subject to injury. They may be pulled from the socket if roughly handled. The hard rubber nut fitted onto the end of the socket should always be kept turned up snug.

JOB 194. INSTALLING AND WIRING AN AMMETER.

1. In some cases cars are not equipped with an ammeter. To install one, first select the instrument of a style suitable to mounting in the space available. Where an ammeter is placed in circuit instead of the "telltale" or "off and on" instrument the same wiring may be used.

2. Cut the instrument or dash board to permit of mounting the ammeter selected.

3. Learn the most suitable points to cut in on the circuit between the battery and the lighting and ignition leads. All current used should be made to pass through the ammeter, excepting, of course, the starting current which is very heavy.

4. Consult the wiring diagram, Fig. 608.

5. Solder and tape all splices.

6. Secure all cables so that they are free of oil, grease, or dirt and likewise of the danger of mechanical disarrangement and injury.

7. Test the instrument when all connections are made. If it shows charge when the lights are burning and the engine idle, the wires on the back of the instrument will want to be changed, or reversed. If it shows discharge, the connection is correct. Fig. 607 shows these connections or binding posts and screws on the back of the ammeter.

Fig. 609. Weston Ammeter for dash mounting.

Fig. 610. Weston Voltmeter.

JOB 195. POLISHING LAMP REFLECTORS.

Lamp reflectors are made from brass, silver plated, then polished very highly. The secret of keeping them bright and in good condition is keeping the air excluded. Excluding the air by means of properly fitted dust rings means that the moisture and road dust will not be carried in as is the case where the small currents of air find their way into the lamp. In case they do become dusty the best way to remove the dust is by means of blowing it away. A stream of compressed air is best for this. Where the reflector is old and tarnished it may be necessary to remove and repolish it. Hand polishing will not restore the original luster but may result in a temporary improvement.

Not all mechanics nor lamp manufacturers are agreed on the proper method to follow in polishing the reflectors when this work is done by hand. The following method is the one recommended by the Gray and Davis Co.

1. Use crocus or rouge with a clean chamois. Have the chamois free of dust and retain it for this purpose alone.
2. To polish use the chamois with rouge dampened with alcohol. This will remove the heavier spots of tarnish.
3. After this is all wiped off with the first piece of chamois, a second piece is used with dry rouge, to give the reflector a very high polish.
4. In polishing use a rotary motion as indicated in Fig. 611.

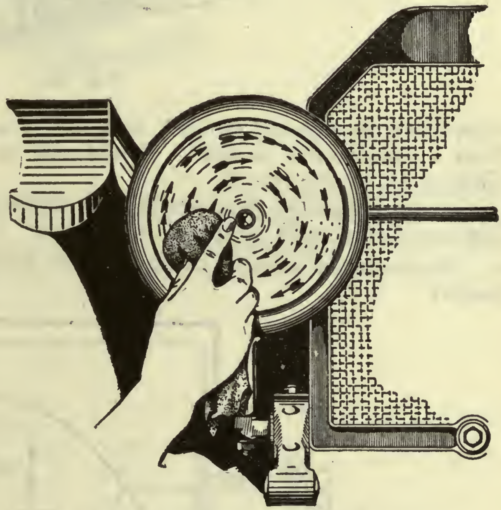


Fig. 611. Polishing Lamp Reflectors.

Not all workmen favor the rotary motion for polishing reflectors. A motion directed from the rim of the reflector to the center is less likely to leave marks. However, either a perfect rotary motion or a direct in and out motion should be used and no attempt made to change promiscuously from one to the other. Neither may good results be expected if a haphazard hit or miss sort of effort is made. Where the chamois and rouge are not available, good results may be obtained from the use of lamp black and a fine grade of tissue paper. Many other methods of greater or lesser value are in use. As a final word of caution it is suggested that whatever materials or polishing stroke is used that the pressure be not too great.

Resilvering of the reflectors is work always handled by the lamp manufacturers or the plating establishments.

JOB 196.

None of the Lights Operate.—If none of the lights operate either the battery is run down, or there is an open circuit between the lighting switch and the battery. Connect the voltmeter across the battery as shown in Fig. 612, using the 30-volt range.

The reading of the voltmeter is the open circuit voltage of the battery.

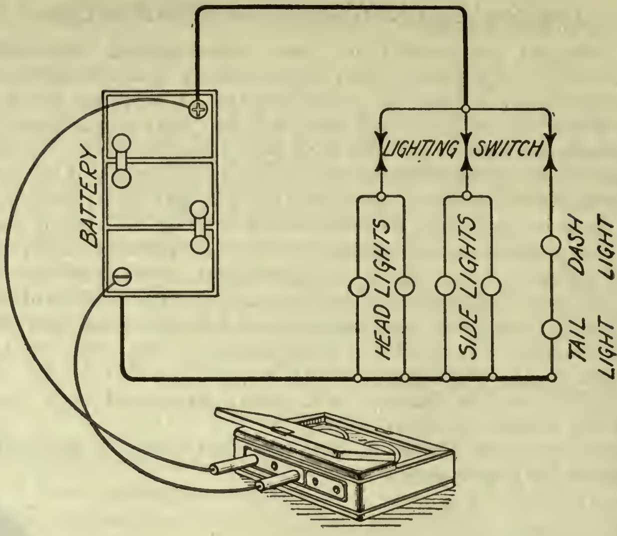


Fig. 612.

Now close the lighting switch. If this is in poor condition the indication will drop a considerable amount. Should this be the case apply tests given in Chapter 11, to the battery.

If the indication does not change when the switch is closed change the voltmeter connection as shown in Fig. 613.

No indication denotes an open circuit between the lighting switch and the battery.

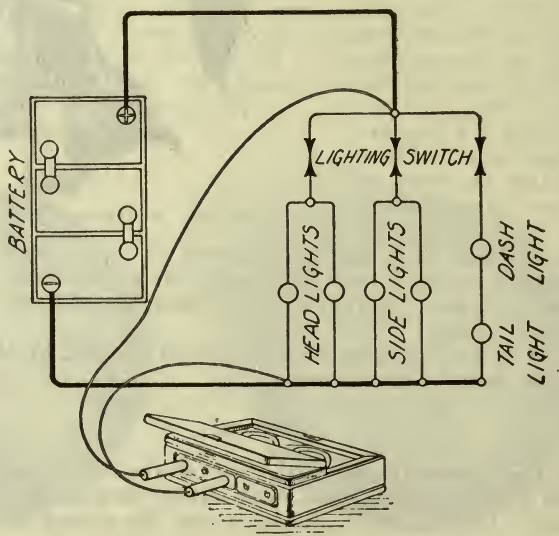


Fig. 613.

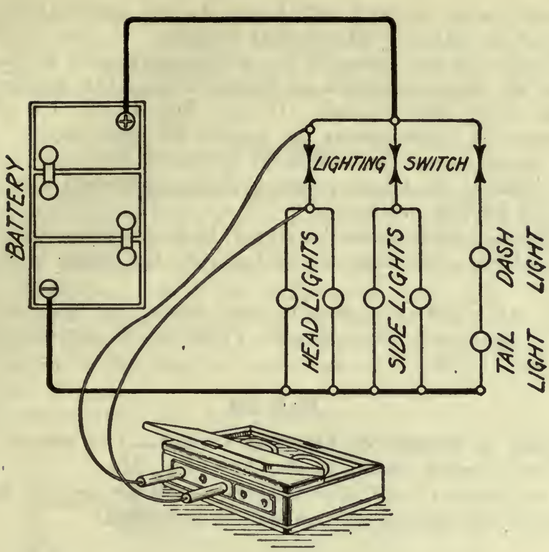


Fig. 614.

JOB 197.

Head Lights or Side Lights Not Operating.—On a six-volt system the head lights and the side lights are connected in multiple as shown in the several illustrations. If, therefore, one of the headlights or side lights does not operate, and the other does, the trouble is very likely to be a burned out light.

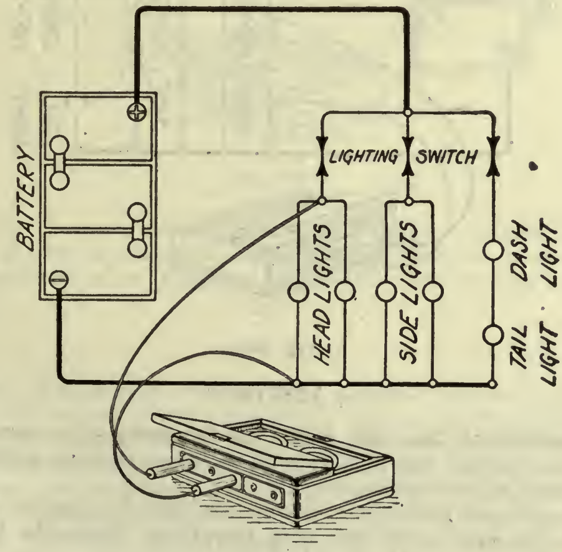


Fig. 615.

If both head lights or both side lights do not operate, the probability is that they are not getting the voltage they require.

In this case the 30-volt range of the voltmeter should be connected across the contacts of the lighting switch as shown in Fig. 614, which is the test for trouble in the head light circuit. If the side lights are inoperative the connection should be made across the switch for that circuit.

With the switch open the voltmeter should indicate the battery voltage. If it does not, change the lamps to see if they are burned out. If the system is fused, look for burned out fuses.

If the reading is equal to the battery voltage close the switch; the reading should now be zero, otherwise the contacts do not close or they are in bad condition.

If the indication does not drop to zero, since the lights do not burn, the chances are that there is a short circuit. This can be determined by applying the test given in Job 198.

JOB 198.

Short Circuit in Branch of Lighting Circuit.—The 30-volt range is connected across the branch circuit as shown in Fig. 615.

If there is a short circuit, the indication will be zero or nearly zero. If in good condition the battery voltage will be indicated.

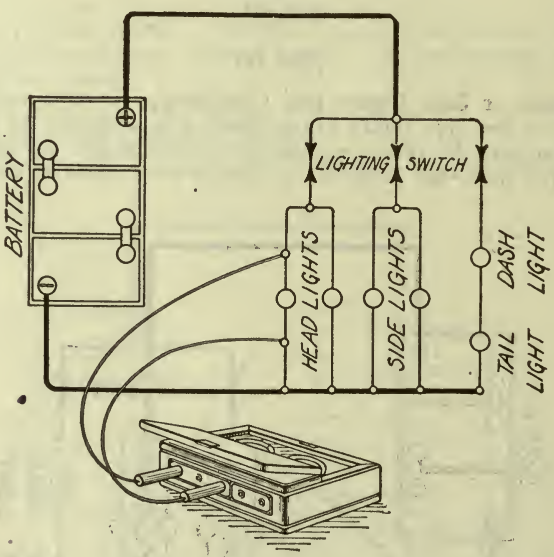


Fig. 616.

JOB 199.

One Headlight or One Side Light not Operating.—As stated in Job 197, the trouble is probably due to a burned out lamp and the quickest test is to replace the lamp by a new one.

If the trouble still exists, then connect the 30-volt range of the instrument, as shown in Fig. 616, across the lamp receptacle. With the lighting switch closed, the voltmeter should show the battery voltage.

If the indication is zero the lamp is not getting any voltage. The wires leading into the receptacle should be examined for open circuits.

If an indication is obtained the trouble may be that the lamp is not making contact with the points in the receptacle, or that it is for a higher voltage.

JOB 200.

Tail Light or Cowl Light Not Operating.—In some systems of wiring the tail and cowl lights are in series and controlled from the same switch, as shown in the illustrations used in this book. With this system of wiring, if one of the lights becomes defective the other will not light either. The simplest test is to replace one of the lights with a new one. If this does not eliminate the trouble replace the other one with a new one. If the trouble still is present, test each receptacle for voltage as in test 199.

If no indication is obtained on either receptacle look for an open circuit somewhere in the wiring.

Other systems control the tail light from the head light or side light

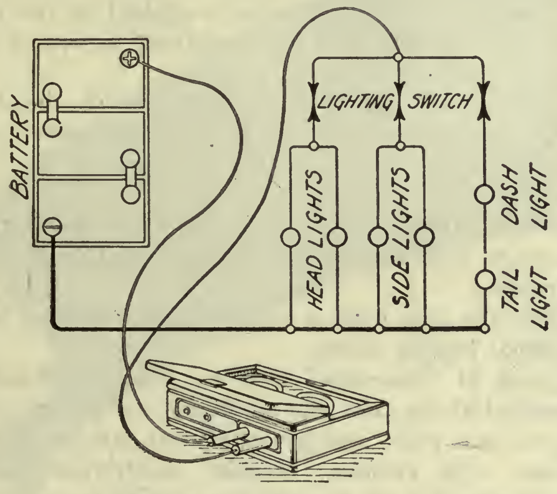


Fig. 617.

switch. In this case tests 198 and 199 should be used to determine the trouble. When such a system of control is used the cowl light has its own switch and should be considered as an individual circuit and tests 197, 198 and 199 should be employed.

JOB 201.

To Measure the Current Taken by the Lights.—Connect the ammeter as shown in Fig. 617 so that it will be in circuit between the battery and lighting switch. As shown with all switches closed, the total lighting current will be indicated. If individual switches are operated separately the current for any particular circuit can be determined, and in the case of lamps in parallel the current for an individual lamp can be determined by removing the one in parallel with it. This test will be found of importance when the various lights do not burn with equal intensity.

CHAPTER 16

TIRE CARE AND VULCANIZING

*THE PRINCIPLES OF TIRE CONSTRUCTION

Fabric Tires.—Although there are many different methods of vulcanizing tires, the methods used may be classified under the general headings of "single cure" and "double cure".

In the case of "single cure" fabric tires, the method of building up is as follows:

The foundation, or carcass, of the fabric tire is built up of close-woven fabric. This fabric is thoroughly impregnated with rubber compound and cut in strips on the bias to the proper width to cover the iron core on which the tire is to be built. When the layers of fabric going under the bead have been applied to the iron core the bead is placed in position and the remaining layers of fabric, going into the tire, are added.

The plies of fabric are then stitched over the bead, alternately, and trimmed. A chafing strip of light fabric is applied over the bead extending from the toe of the bead to a point ½″ to ¾″ above the bead proper.

The cushion, breaker, side walls, and tread are then applied and the tire placed in a mold, in which the non-skid pattern of the tread is cut, and cured.

Sometimes the iron core is removed and replaced by an air bag which is inflated before curing.

In the case of "two-cure" tires the carcass is built up in the manner described above; the side walls and top covers are put on and the tire is put in a mold and given a semi-cure in order to set the fabric carcass. The cushion, breaker, undertread and semi-cured tread band are then put on, the tire is wrapped and given a final cure by hanging the tire in a heater. Sometimes the cushion and breaker are put on and cured in the first cure.

There are two methods of handling the tires during the second cure. In one case the tire is allowed to remain on the core during its entire construction, being cross wrapped on the core for second cure. In the second method the core is replaced by an air bag and the tire is put on a curing rim before being wrapped. The bag is then inflated.

Cord Tires.—The manufacturing operation in the case of cord tires is very much the same as for fabric tires. They are usually cured by some internal pressure process, such as the air bag.

*Courtesy Goodyear Tire & Rubber Co.

The chief difference in a cord tire is that the carcass is built up of what is known as cord fabric. This is a fabric made up of cords all parallel to one another and held in place by a few light "tie-in" cords.

The patented Goodyear method of building cord tires reduces the friction to a minimum between these cords, thus greatly increasing the mileage delivered, and facilitating repair work.

This construction is briefly as follows: Four groups of plies are used, separated from each other by a thin cushion. In each group the number of plies depends on the size of the tire. The different plies are put on so that the cords in each group run in the same

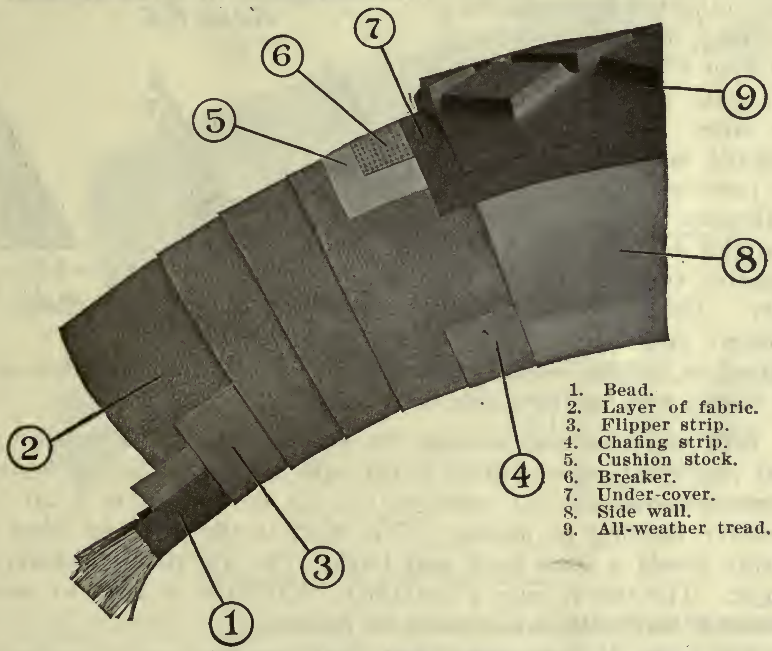


Fig. 618. Fabric Tire Construction.
(Courtesy Goodyear Tire & Rubber Co.)

direction. The direction of the cords is changed in each group so that the cords of one group run at 90° to the cords in a corresponding group.

Fig. 620, cord tire, shows the construction labeled the same as the fabric tire.

Tire Care.—The realization of just how much the proper care of tires means to the user in eliminating trouble and excessive costs of tire service is the biggest step in securing absolute satisfaction. For best service note the following suggestions:

Truing Up Wheels.—Often, through an accident of some sort, a misalignment of some kind occurs and one tire is forced to slide or scrape sideways over the ground instead of running in a natural

manner, because the wheel itself does not run true. The axle may be bent up or down, or forward or backward, so that the wheel slants or wabbles as it runs. The rapid wear on the tread of such a tire will continue until a mechanic realigns the wheels.

Tread Cuts.—The knowledge of how to care for tread cuts is of the greatest importance to tire users. Every sharp object the tire passes over may, if hit squarely, inflict a cut which, if neglected, will cause the loss of many tire miles. This should be carefully inspected at regular intervals and if these small cuts are found, they should be cleaned out, cemented and filled with tire putty. This keeps out all moisture and dirt which it allowed to remain, would cause ply separation and a weakening of the fabric, with an inevitable blow-out.

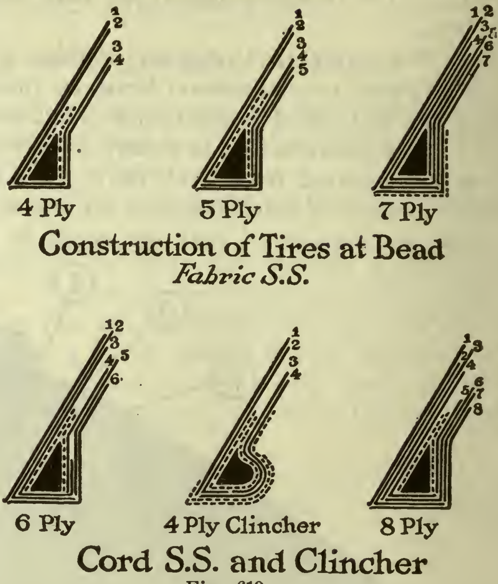


Fig. 619.

Inflation.—Gaining mileage by proper inflation is possibly the most important consideration in the care of tires. Plies of fabric or layers of cords will not continue to bear the weight of a car with excessive bending or flexing. The effect is the same as when one sharply bends a wire back and forth. The air should sustain the weight. The tire is only a container. Each tire is built to carry a maximum load with a minimum air pressure.

Fabric Breaks.—Fabric breaks are caused by hitting some object which flexes the tire to the breaking point at any point in the tire. It is also caused by overload or under-inflation. This break occurs on the inside of the tire and may appear as a slight wavy line on the inside ply, or an open break in the plies. The proper care of these fabric breaks is valuable information. The casing should be examined frequently and if a fabric break is indicated on the inside a sectional or full circle reliner should be inserted until a permanent repair can be made. An outside protector may also be necessary.

TIRE REPAIR MATERIALS

The Goodyear line of repair materials is shown here in order that the student may familiarize himself with the trade names and

methods of listing the various gums, cements, and other materials used in the repair of tires. The repair materials described are representative of best practice in the tire repair business. Other companies manufacture similar materials but they would not bear the same catalog numbers as those shown for the Goodyear line.

Tread Gums.—G-100, G-105 and G-115 tread stock are used for tread repairs, side wall repairs and as an under cover stock. It may also be used in making negative pads for preserving tread designs.

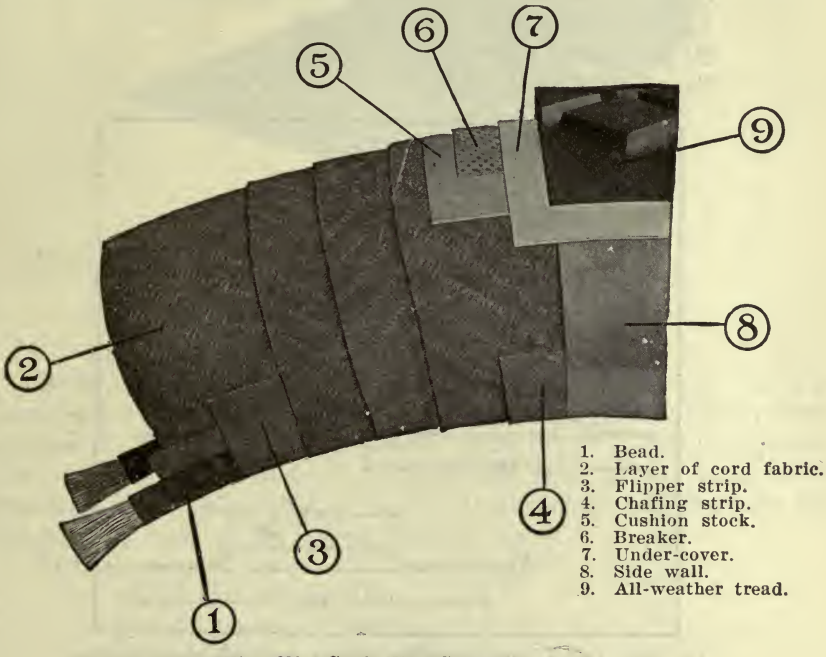


Fig. 620. Cord Tire Construction.

G-100.—G-100 White Tread Gum is exceedingly durable, possessing the three essential qualities—toughness, strength and resiliency. It also flows readily in the "cure".

Furnished as follows:

5 pound cartons, 12″ wide.
12½ and 25 pound rolls, 18″ wide.
50 and 100 pound rolls, 36″ wide.
Standard gauge, 1/16″.

G-105.—G-105 Black Tread Gum is in great demand owing to the predominance of black tread tires. It is "tacky" and pliable before it is cured. It flows easily and smoothly during the cure. It is tough, strong and resilient after it is cured. This gum has been so compounded that it will not bloom out readily.

See Camel Back.

Furnished as follows:

5 pound cartons, 12″ wide.
12½ and 25 pound rolls, 18″ wide.
50 and 100 pound rolls, 36″ wide.
Standard gauge, 1/16″.

G-115.—G-115 Grey Tread Gum is a tough and resilient stock which flows easily and smoothly during the cure.

Furnished as follows:

5 pound cartons, 12″ wide.
12½ and 25 pound rolls, 18″ wide.
50 and 100 pound rolls, 36″ wide.
Standard gauge, 1/16″.

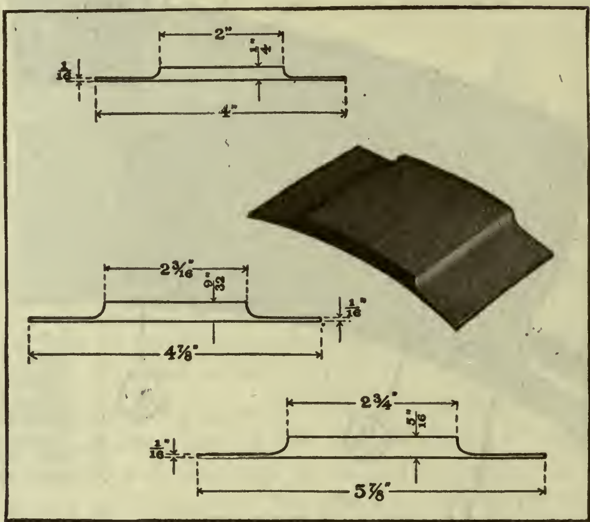


Fig. 621. Camel Back, showing various sectional measurements.

Camel Back.—The Camel Back has been developed to take care of the increasing demand for a tread stock ready for application. Goodyear Camel Back is so compounded that it combines all of the qualities incorporated in a perfect wearing tread gum. Its design is such that it gives perfect results when cured in the third circle retread mold. Goodyear Camel Back is black and of the same compound as G-105 Tread Gum.

Furnished as follows:

No. 1 Style for 3″, 3½″ tires, 15 and 25 pound rolls.
No. 2 Style for 4″, 4½″ tires, 15 and 25 pound rolls.
No. 3 Style for 5″ tires, 15, 25 and 50 pound rolls.

Cushion and Tube Repair Gum, G-170.—G-170 is a cushion stock of highest quality, being practically a pure gum with just enough compound to effect the cure. It is strong, lively and resilient, thereby

possessing all of the necessary qualities to make it desirable for a good cushion stock. It may be used in repairing inner tubes and when properly dissolved makes a good cement.

Fig. 622. Tread and Sidewall Gum.

Furnished as follows:

5 pound cartons, 12″ wide.
12½, 25 and 50 pound rolls, 18″ wide.
Standard gauge, 1/32″.

G-180.—G-180 is a quick cure gum for tube repairing. It is so compounded that it will cure in five to ten minutes at 60 pounds steam pressure or 307.2 degrees Fahrenheit. The use of G-180 in repairing tubes lessens the chance of burning the tube. It is particularly recommended for this kind of work. It stretches with the tube and will not pull loose at the edges, chip, or crack.

Furnished as follows:

1 pound cartons, 5″ wide.
5 pound cartons, 12″ wide.
12½ and 50 pound rolls, 18″ wide.
Standard gauge, 1/32″.

G-190.—G-190 Cured Back Tube Gum is a combination of cured and uncured stock. It is so compounded that it will stretch with the tube but is tough and strong and makes an excellent reinforcement. This gum is for inside reinforcement on tube repairs—using G-180 for outside work.

Furnished as follows:

1 pound cartons, 5″ wide.
5 pound cartons, 12″ wide.
12½, 25, 50 and 100 pound rolls, 36″ wide.
Standard gauge, 6/128″.

Repair Fabrics, HF-41.—HF-41 Repair and Rebuilding Fabric is a 14-ounce, closely woven Egyptian fabric, impregnated with the finest quality friction. The fibres of the fabric are actually 1⅜″ long.

The friction is practically pure gum. Such a combination insures strength and durability. This fabric should always be cut on the bias.

Furnished as follows:

Friction two sides.
Bareback (frictioned one side only).
Frictioned two sides, skim-coated one side.
5 pound cartons, 12″ wide (cut on bias).
12½ and 25 pound rolls, 40″ wide.

LF-52.—LF-52 Bead Fabric is a strong 7½ ounce fabric impregnated with fine quality friction.

It has three purposes, being highly efficient as a bead cover fabric, a motorcycle tire rebuilding fabric, and a bicycle tire rebuilding fabric. It is also used as a backing for negative pads.

Furnished as follows:

2½ pound cartons (cut on bias), 12″ wide.
Also furnished in 12½, 25 and 50 pound rolls, 60″ wide.

CF-44.—CF-44 Cord Fabric is made up of materials similar to those used in Goodyear Cord Tire construction. It is used for making small inside reinforcements that are too small to warrant the expense of a cord patch, and for making large sectional repairs in cord tires where the injury in the carcass is too extensive to be repaired with a cord patch.

Furnished as follows:

5 pound rolls, 12″ wide.
12½, 25 and 50 pound rolls, 48″ wide.

Fig. 623. Tube Repair Gum.

BF-23.—BF-23 Breaker Fabric is made up of a high quality fabric, frictioned both sides, skim coated both sides with a gum of the same compound as G-170. This insures the best possible union

between the cushion and breaker, and the breaker and tread or undertread.

Furnished as follows:

5 pound rolls, 12″ wide.

12½ and 25 pound rolls, 48″ wide.

Cord Patch.—Goodyear Cord Patch offers one of the most satisfactory and also the simplest method of making a permanent repair of ordinary carcass injuries in fabric and cord tires. The Cord Patch properly vulcanized usually outlasts the rest of the tire, and adds many tire miles.

It is a sectional reinforcement, for inside application, consisting of several layers of cord fabric such as is used in the construction of Goodyear Cord tires. Full instructions for application are furnished with each patch.

Furnished as follows:

No. 1 for 3½″ and 4″ tires.

No. 2 for 4½″ and 5″ tires.

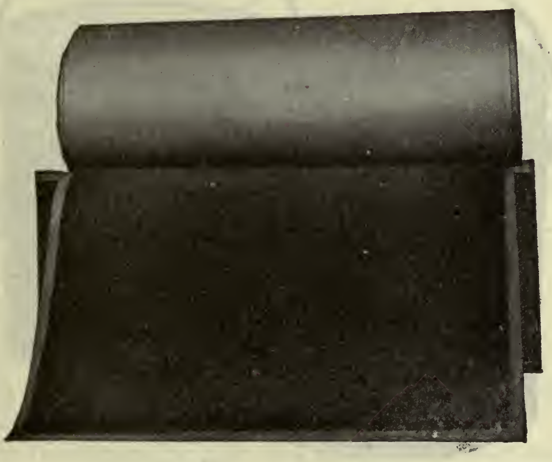


Fig. 624. Repair Fabric.

Vulcanizing Cement, C-15.—C-15 Cement is made of the highest quality materials and is of a heavy consistency. One gallon will make two gallons of good cement when thinned down with a good solvent.

Furnished as follows:

Pint cans, 1 gallon cans and 5 gallon cans, 55 gallon steel drums.

C-16.—C-16 Cement is the same as C-15. It has been thinned to the proper working consistency. This cement is furnished because many repair men find it difficult to obtain a high grade solvent for thinning C-15 Cement.

Furnished as follows:

1 gallon and 5 gallon cans.

55 gallon steel drums.

C-25.—C-25 Cement is a quick cure vulcanizing cement especially compounded for use with G-180 and G-190 Tube Repair Gums. It is also used in the application of Goodyear Cord Patches.

Furnished as follows:

1 pint cans, 1 gallon and 5 gallon cans.

55 gallon steel drums.

C-35.—This cement is of the finest quality and is used for applying valve patches, splicing inner tubes, applying cold patches of any description and reliners. It is a self-curing cement.

Furnished as follows:

1 pint, 1 gallon and 5 gallon cans and 55 gallon steel drums.

Fig. 625. Regular Cure Vulcanizing Cement.

Reliners.—The Goodyear Reliner, properly applied, acts as a new backbone to a "worn" casing and usually adds many miles to its life.

Furnished as follows:

30 x 3	3 ply	32 x 4	4 ply	35 x 4½	4 ply
30 x 3½	3 ply	33 x 4	4 ply	36 x 4½	4 ply
32 x 3½	3 ply	34 x 4	4 ply	35 x 5	4 ply
31 x 4	4 ply	34 x 4½	4 ply	37 x 5	4 ply

Goodyear Reliners are made of high grade, new American fabric. The ends and sides are stepped down to a feather edge. The ends have rubber tips which prevent chafing where the ends lap.

Valve Patches.—The patches are made of tough resilient rubber,

reinforced in the center with two plies of fabric. They are rigid next to the valve, but the edges stretch readily with the tube.

Furnished as follows:

No. 1 for 3", 3½", 4", 4½" and 5" tubes.

Semi-Cured Retread Bands.—Goodyear Retread Bands are of the same quality and dimensions as the treads on Goodyear Tires and excel in wearing qualities, construction and appearance.

Goodyear Retread Bands give exceptional service when applied with under-cover stock (G-100, G-105 and G-115) and are cured properly. The system of grouping sizes enables the repairman to take care of all passenger car size tires by stocking only five sizes and two styles of retread bands.

These bands may be had in either the All-Weather or Ribbed Tread.

Soapstone.—Goodyear Soapstone is the best grade that can be purchased. It should be used in the form of a stiff paste to preserve tread designs, and to dust over repairs to prevent them from adhering to the molds and inner tubes.

Furnished in:

25 pound sacks.

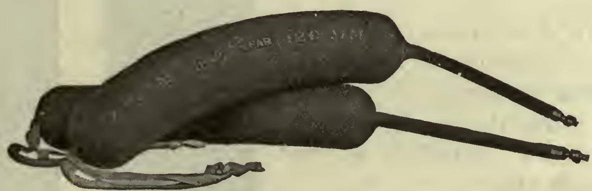


Fig. 626. Sectional Air Bag.

Sectional Air Bags.—Goodyear Sectional Airbags are made of a specially compounded gum and high grade closely woven fabric. The inside is lined with a heavy gum tube especially compounded to retain its good qualities even after long continuous use.

The bag is reinforced at each end with a reinforcement of heavy fabric. A loop of tape is attached to facilitate removing the bag from the casing. Instructions as to the proper use and care of sectional airbags are furnished with each bag.

Furnished as follows, in ¼ circle and 1/5 circle:

3", 3½", 4", 4½", 5" and 5½" bags.

WHY REPAIRS FAIL

Most repair failures are due largely to oversights and carelessness on the part of the repairman. They happen mainly because a detail of a process has been overlooked. Repairmen, as a general rule, are quite sure of their materials and major methods. However, if they are kept busy with customers as well as doing the actual work

in the shop and are called frequently from their work, the repair work is bound to suffer. Repairing requires careful supervision. The master repairman who is required to take care of customers should have an assistant well trained to do this supervising.

1. Cement, if not allowed to dry thoroughly, causes a porous condition between new and the old material. This condition will show up black and glossy. The pores will be small.

2. Cement, if allowed to dry too long, loses its adhesive properties, thus permitting separation. This condition can properly be called "air cure" because the air attacks the cement, causing one form of cure.

3. If dust is allowed to settle on the repair before it is completed and it is not removed, it permits separation after the cure, because the plies of raw materials do not adhere to each other.

4. Oil or grease may be in either the old tread or the casing as well as in the solvent or gasoline. This is caused by the tire standing in pools of oil or by running on oiled roads, especially when the tread is badly cut. This allows the oil to soak through and penetrate to the fabric in the carcass.

5. Lack of pressure in a cure also causes a porous condition. In most cases it can be detected by poor flow of the raw material. It is caused by leaky sectional airbags, poor bead molds or bad clamps or from sectional airbags not fitting the inside of the casing properly.

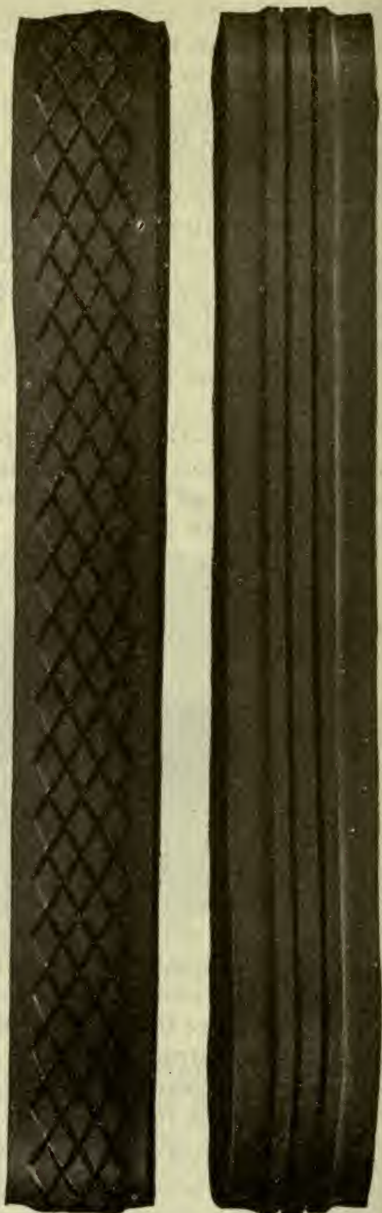


Fig. 627. Semi-Cured Tread Bands.

6. Buckles inside the casing, and cracks on the outside of the casing along the tread line in sectional repairs are usually caused

by too much pressure exerted on clamps in placing the casing in the cavity of the mold. The mold cavity is then smaller than the casing.

7. Clamps properly fitted should be just tight enough to form a complete mold around the casing.

8. Do not handle repair material any more than can possibly be helped.

9. In washing a repair with solvent the rag should be slightly moistened and not saturated.

10. Occasionally it is found that after curing a casing, the first layer of fabric bulges and upon opening it with an awl gas comes out. This condition is usually caused by a deteriorated condition of the carcass.

SUGGESTIONS FOR HANDLING REPAIR MATERIALS

1. Raw gum and fabric should be kept in a cool, dry place.

2. If possible, the stock room should be dark. It is imperative that the raw stock should not be near an open window nor in a direct draft or sunlight. Dampness should be avoided. Raw stock should never be allowed to stand on the floor or on a table. Wherever possible, they should be placed on a rack with a rod running through the shell on which the material is rolled.

3. In warm weather raw gums will sag from their own weight, even when tightly rolled on the holland. To overcome this, it is advisable to turn the stock at frequent intervals.

4. Repair gums and fabric received in cold weather sometimes appear hard and lifeless. They are merely frozen. Freezing does not affect the stock. If received in this condition it should be put in a warm room a short time to thaw out.

5. In order to get good results from a repair it is essential that the stock be perfectly clean when used.

6. Dirt and bloom, or free sulphur, always collect on uncured rubber. If this is not thoroughly washed off with gasoline before used in a repair, an imperfect union will surely result.

7. Gums and fabrics that have bloomed sometimes appear old and do not appear to be in condition to be used. If the bloom and dirt are washed off with solvent, the gum will give good results.

8. The quality of gums or fabric is not necessarily determined by the length of time before they start to bloom. All uncured gums are bound to bloom eventually.

9. Always save your scrap gums. They can be returned for credit. The value of this material when returned depends largely upon its condition. The gums should be kept separate and free from foreign materials.

10. All repair fabrics should be cut on the bias at an angle of 45 degress. A repair made of fabric cut on the straight becomes hard and often bulges.

11. Tread stock dissolved in gasoline or solvent does not make a good vulcanizing cement. It is also costly.

12. The most economical plan to make cement is to buy good grade cement gum.

13. Make test cures of your raw gum and fabric at least once a week.

14. For testing open heat and sectional repair work, build up a section on an old tire and cure in the usual manner. Cut from this cured section a piece about an inch wide and separate the different stocks wherever there should be a union.

15. By pulling these slowly, it is easy to see whether you are getting good strong unions in your cure. You can also judge as to the cure by the condition of the stock.

16. A good method of testing rubber for cure is to cut a narrow strip about ⅛″ wide in the edge of the piece to be tested. By pulling this, the elasticity and "set" can be determined. A well cured stock should be elastic and lively, and the strip should return to very nearly its original length.

17. When raw gums do not flow, it is a pretty sure sign of insufficient pressure on the inside of the casing.

18. Always inflate sectional airbags to 70 pounds pressure. If the bag or coil is not large enough to fill out the casing properly it should be padded with strips of old fabric until it fits snugly.

19. Be sure that the fabric in the casing to be repaired is dry before you proceed with a repair. Fabric separation will result from failure to heed this warning. An inside patch vulcanizer serves as an excellent drier. Temperature should not exceed 150 degrees F. in drying.

20. If extensive repairs are made on casings with separated fabric, the heat during the cure will expand the air between the plies and increase the separation.

21. When cutting rubber, dip your knife in water. It lessens the resistance.

22. The best way to repair a leaky splice is to insert a new section.

23. The life of an airbag can be greatly prolonged if the bag is handled properly.

24. Do not use an airbag as a building form.

25. Do not remove the air bag from the casing by pulling it by the stem.

26. When the tire has been placed in the mold, do not fasten

the clamps down securely until after the airbag has been partially inflated.

27. Always dust the airbag slightly with soapstone before using.

28. When in use keep the sectional airbag inflated to 70 pounds pressure.

29. If a bag becomes porous, it can be repaired by forcing a small quantity of C-15 vulcanizing cement through the stem and into the bag.

30. Here is the method to use in doing this.

31. After removing the valve inside, clasp the bag between your hands, and exhaust as much of the air in the bag as possible.

32. Place the stem of the bag in the cement and release the pressure gradually until a small quantity of cement has been drawn in. Then roll the bag around so as to get the cement distributed over the inside. Allow the cement to dry.

33. Repeat the operation three times (using in all about one-fourth pint of cement). The bag is now ready for use.

34. When a tube splice is made by the acid cure process and it does not hold, it can usually be traced to one of the four following causes:

35. The cement was not dry.

36. The acid was too weak.

37. The splice was not made quickly enough after the acid was applied.

38. There was insufficient pressure on the splice after the union was made.

39. After an inner tube has been repaired, always test it in water to make sure that there is not another leak.

PRACTICAL VULCANIZING HINTS

1. Undercuring of sectional repairs can often be traced to the molds. If the molds are clogged with dirt, or if air pockets are allowed to form in the molds, it takes longer to heat them and consequently, longer to cure the repairs.

2. Water collects in the molds occasionally, stopping circulation, with the result that, while the pressure may be correct, the temperature of the molds will be too low to accomplish the cure in the prescribed time.

3. At least once a month the steam pipe should be disconnected and a strong current of compressed air should be blown through the molds.

4. A surprising amount of dirt and water will be dislodged by this process.

5. There will be comparatively little trouble from this source if your molds have a drain at the lowest point, where water is likely

to collect, and a pet cock at the highest point to allow trapped air to escape.

6. An airbag that has been used in several cures becomes elongated and may extend beyond the ends of the sectional mold. This causes a ridge on the tire at the ends of the mold. To prevent this, bevel the edges of the mold back about half an inch.

7. Small cuts and fabric breaks in motorcycle tires can be repaired on the tube plate.

8. It is very important to know the relative degrees of temperature to pounds of steam pressure. The following table gives this information:

Temperature F	Pounds Steam Pressure	Temperature F.	Pounds Steam Pressure
227.2	5	280.6	35
239.4	10	286.7	40
249.8	15	292.4	45
258.8	20	297.7	50
266.8	25	302.6	55
274.0	30	307.2	60

This table will not hold true in extreme altitudes or climates. In such cases it is well to revise the table with the use of a thermometer so that you can be sure of getting the required temperature, with the designated steam pressure.

9. All metal surfaces that come in contact with the raw gum during the cure should be kept highly polished and perfectly clean.

10. Clean your molds or cores as follows:

First, polish with fine emery paper or wire cloth. Then apply a solution of soap and water, or soft soap by means of a large paint brush.

11. In making cement, take a quantity of raw gum and cut it up in small pieces. Then place in a can together with a small quantity of high test gasoline and stir every hour or two until the gum has dissolved to the consistency of cream.

12. Cement should be thoroughly stirred each time it is used or the results are bound to be variable, due to the settling out of curing agents. Cement is like paint in this respect.

13. C-15 Cement, when ready for use, should be of a consistency similar to that of cream or house paint. It should flow readily.

14. If C-15 Cement is found very heavy when purchased, or if it becomes very thick, it may be thinned with a good grade of gasoline (one that shows no oil residue) or benzol.

15. Where several gallons of cement are required daily, a small barrel or churn can be used to advantage for mixing.

16. During the time that C-15 Cement is being used, it should

be stirred frequently. Poor results will be obtained unless this is done.

17. Never hang cemented tires in a draft or over vulcanizers to hasten the drying. Allow the drying process to take its natural course.

18. Vulcanizing Cement can be thinned by the use of a good rubber solvent.

19. Gasoline that will not leave a grease spot on white paper after it has been allowed to evaporate is a good solvent.

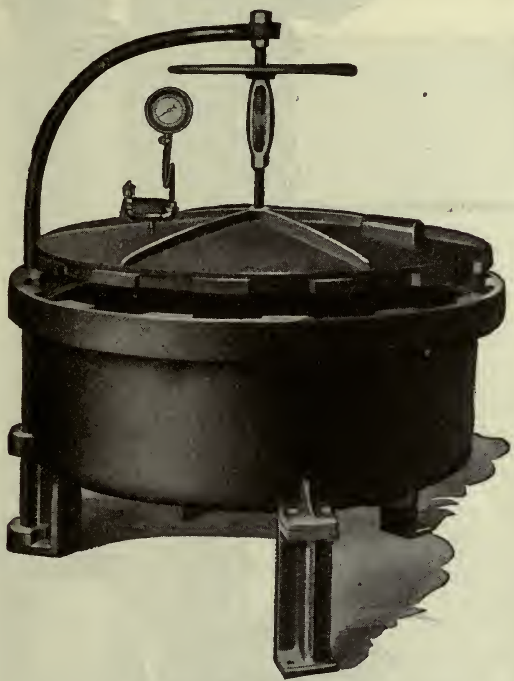


Fig. 628. Akron-Williams Vulcanizing Kettle.

20. Benzine or energine are both good solvents and can be relied upon.

21. Grain or wood alcohol is not a rubber solvent and should never be used. The cement may appear thinner but it is of poorer quality. Instead of acting as a solvent it causes coagulation of the rubber particles.

22. So-called "high grade" or "more power" gasolines contain substances which make them unfit for use with rubber cement.

23. Low gravity solvents contain greasy residues which are detrimental to cement.

24. Solvent should be added a little at a time and then stirred thoroughly before any more is added.

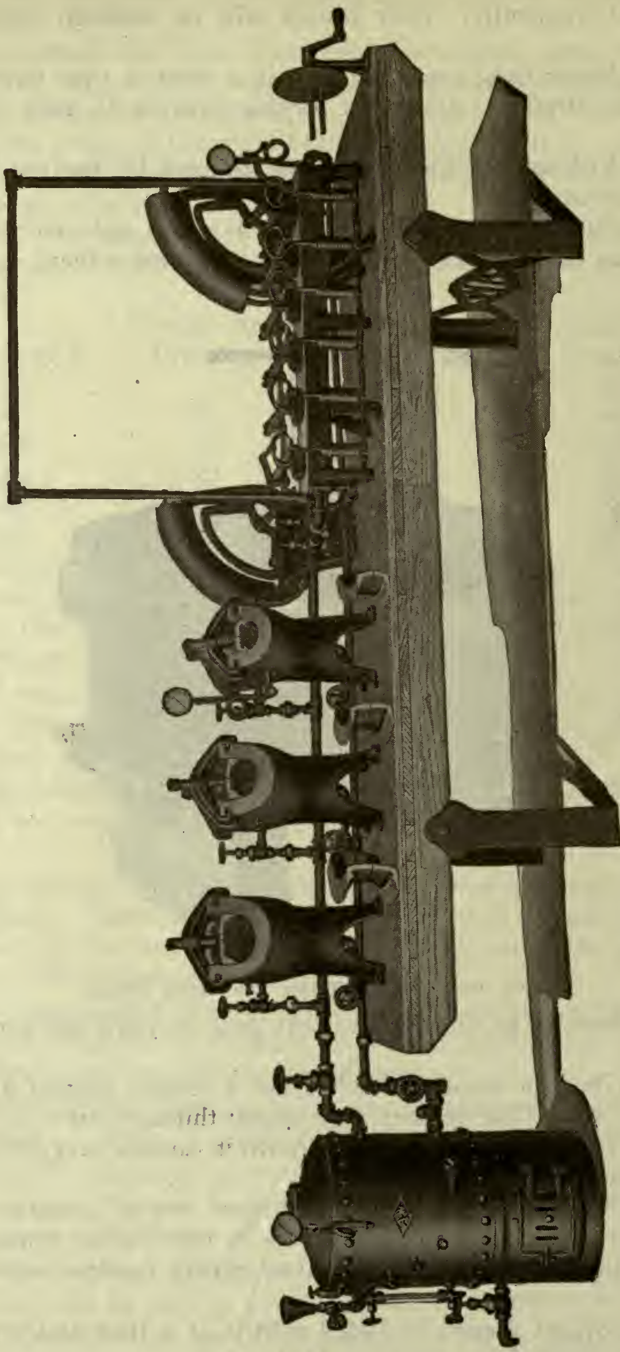


Fig. 629. Akron-Williams, Model 133-R, Vulcanizing Outfit.

25. Cement should be kept in covered containers when not in use.

26. Whenever possible cement should be stored in a cool, dry room to prevent evaporation of the solvent.

VULCANIZATION

Vulcanization so changes the physical properties of rubber as to render it less plastic and more resistant to wear and mechanical strains. Vulcanized rubber is a product resulting from the chemical union of crude rubber and sulphur, and as heat accelerates all chemi-

Fig. 630. Curing on hot plate.

cal reactions we have employed the aid of steam to bring about a quick union of crude rubber and sulphur.

It is generally known that other chemicals than sulphur are also used in compounding. These chemicals do not unite with the rubber but are highly dispersed throughout the mass and their presence gives to the rubber certain desirable properties such as resistance to wear and abrasion, resiliency, and strength.

Sulphur and rubber combine very slowly under atmospheric conditions and this is what we call spontaneous cure. It takes months

for this curing to materially affect the physical properties of the product, so we find this matter of little importance to the average vulcanizer.

Now, according to certain laws of chemistry, an excess of any element entering into a chemical combination greatly accelerates the speed of reaction. It is for this reason that it is necessary to use an excess amount of sulphur. However, this excess, unless it is too great, does not in any way affect the physical properties of the vulcanized rubber. Rubber blooming is nothing but the excess of sulphur in the vulcanized rubber working to the surface.

It is also true that some of this excess sulphur never blooms, and as rubber ages there is a slow process of spontaneous vulcanization going on which is called "aftercure". It is for this reason that rubber when very old becomes hard and lifeless and has a tendency to chip easily.

Well made repair materials are compounded with the correct amount of ingredients so that when properly cured the effect of "after cure" is reduced to a minimum. For the above reasons, to get good results it is absolutely necessary to use the temperatures and time recommended for curing the different repairs.

Cures.—Following cures are recommended for curing passenger car tire and tube repairs:

Tube Repairs.—The length of time necessary to cure a repair depends on its thickness. G-180, cured in thin sheets, cures in five minutes at 60 pounds steam pressure. However, when built up in repairs, a somewhat longer time must be allowed in order that the heat may penetrate and give a good cure throughout.

On Tube Plate at 60 lbs. Steam Pressure:

G-180 alone, five to eight minutes.

G-180 with G-190 reinforcement, ten to twelve minutes, depending on the thickness used.

On Tube Plates at 40 lbs. Steam Pressure:

G-180 alone, ten to fifteen minutes.

G-180 with G-190 reinforcement, eighteen to twenty-five minutes, depending on the thickness used.

Valve Patch with C-25 Cement. Cure 12 minutes at 40 lbs. Sectional Work (Built up as Described):

For full section and half section and quarter section.

For Smooth Tread:

3″, 3½″ .... 55 minutes at 40 pounds
4″ .... 60 minutes at 40 pounds
4½″ .... 65 minutes at 40 pounds
5″ .... 70 minutes at 40 pounds

Note: Add twenty minutes to time of cure when negative pad is used to preserve the tread pattern. Add fifteen minutes to time of

cure when soapstone and jacket are used to preserve tread pattern. In curing a **quarter section** the additional time allowance for matrix or soapstone need not be added to the cure.

Cure full section built in tire which has tread cut off for retreading:

3″, 3½″..25 minutes at 40 pounds
4″, 4½″, 5″.....................................30 minutes at 40 pounds

Top Section: In sectional mold (2 plies stepped out).

For Smooth Tread:

3″, 3½″..50 minutes at 40 pounds
4″, 4½″..55 minutes at 40 pounds
5″...60 minutes at 40 pounds

Note: Allow fifteen minutes additional time when soapstone and jacket are used to preserve the tread; twenty minutes when matrix is used.

When top section is built in retread cure in regular manner.

Side wall Cuts:

Cure on hot plate or in sectional mold 50 minutes at 40 pounds when no plies have been cut out.

When outer ply has been stepped out, cure as recommended for quarter section.

When strengthening plies are put inside tire, cure same as retread in kettle.

Cure for Negative Pad or Matrix:

20 minutes at 40 pounds in sectional mold.

Tread Repairs:

Cure 45 minutes for cuts about ⅛″ deep; 60 minutes for cuts about ⅜″ deep.

Retread with All-Weather or Rib Tread Band:

3″, 3½″, 4″..................................50 minutes at 40 pounds
4½″, 5″..55 minutes at 40 pounds

In retreading kettle.

One-Third Circle Retreading:

Cure at 40 pounds steam pressure:

No. 1 Camel back, 3″, 3½″—55 minutes at 40 pounds steam pressure.

No. 2 Camel back, 4″, 4½″—60 minutes at 40 pounds steam pressure.

No. 3 Camel back, 5″—70 minutes at 40 pounds steam pressure.

Cure at 50 pounds steam pressure:

No. 1 Camel Back, 3″, 3½″—45 minutes at 50 pounds steam pressure.

No. 2 Camel back, 4″, 4½″—50 minutes at 50 pounds steam pressure.

No. 3 Camel back, 5″—60 minutes at 50 pounds steam pressure.

JOB 202. REPAIRING PIN HOLES AND SMALL PUNCTURES.

1. "Pick out" puncture to a small open injury.
2. Buff with emery cloth—stretch tube so that injury can be buffed thoroughly.
3. Wash with solvent to remove dust.
4. Apply two coats of C-25 quick cure cement overlapping the injury.
5. Then "drive" small "thread" of G-180 tube gum through injury so that it will form a rivet head on inside of tube.
6. Fill up injury flush with outside surface of tube—do not overlap on the outside.
7. Cure according to chart.
8. It is always well to use a piece of holland on the tube plate.

Fig. 631. Correct method of stitching in gum.

JOB 203. REPAIRING LARGE INJURIES AND BLOW OUTS IN TUBES.

1. Ragged edges of injury should be trimmed and thoroughly buffed.
2. Buff the side of the injury and the inside of the tube for a distance of 1″ around this injury. Wash this surface with a rag moistened with solvent.
3. Apply both inside for a distance of 1″ around the break and to the edges of the break two coats of C-25 quick cure cement.
4. Cut a piece of G-190 cured back tube gum with rounded corners, ¾″ larger than the injury. Insert on inside of injury with raw gum side next to the tube.
5. This inside reinforcement patch can be inserted by holding the patch with a pair of long-nosed pliers. Dip it in solvent and insert it before the solvent dries. When this is done, care should be taken to hold the reinforcing patch away from the tube on the inside, in order to allow the solvent to evaporate before stitching down the patch.
6. Fill up the injury, on outside, with G-180 tube gum, flush with the outside surface of the tube. Do not overlap at edges. This should not be

filled in until the reinforcing patch has been allowed to dry for at least ten minutes.

7. Cure on tube plate, according to chart.

Fig. 632. Injury trimmed out ready for repair.

JOB 204. SPLICING INNER TUBES.

1. New section inserted in the tube should be 5″ longer than the old section cut out, thus allowing 2½″ for the splice at each end.

2. The edges should be beveled to feather edge at an angle of approximately 40 degrees.

3. One edge should be beveled from the outside and the other edge from the inside.

4. The edges of the inner tube itself should be beveled in the same manner as the section to be inserted.

5. Both tube and section should be buffed with emery cloth or wire buffer, 3″ from each end. One end of the tube and section should be buffed on the outside and the other end on the inside. To facilitate buffing the tube may be put on a mandrel.

6. One end of the section should be lapped back 2½″ on the female tube mandrel.

7. The end of the tube itself should be lapped back 5″ and then folded back on itself 2¼″ on the male tube mandrel.

8. Apply two coats of C-35 acid cure cement.

9. Allow the first coat to dry twenty minutes; second coat, thirty minutes.

10. The two ends are then placed in position and acid or curing solution is applied.

Fig. 633. Inserting inside reinforcement.

11. The lap on the female mandrel should be pushed quickly over the male mandrel and tightly wrapped with strips of rubber or cloth.

12. Allow the splice to be wrapped for approximately thirty minutes.

Fig. 634. Filling up injury on the outside.

13. It is always well to slide the female mandrel forward so that 1½″ of tube remains after cementing. This eliminates the possibility of an overlap at splice.

14. After applying acid or curing solution, the ends should be placed together and wrapped in less than eight seconds to insure perfect results.

ACID CURING SOLUTION.

Acid curing solution may be secured from the druggists or from the drug supply houses. The formula for this solution is given below:

Fig. 635. Tube on mandrel ready to splice.

1.7 fluid oz. Sulphur monochloride (S C1) to 1 gal. Carbon tetra-chloride (CC1).

It is possible to vulcanize a splice on the tube plate. Those desiring to use this method should follow directions given in Job 205.

JOB 205. VULCANIZED TUBE SPLICE.

1. Cut out the bad section of the tube to be spliced.

2. From another tube of good rubber cut a section 5″ longer than the one removed. This permits of a splice at each end of 2½″.

3. Turn back the ends of the section or tube. Roughen edges of both section and tube 2¾″ from the ends. Clean with gasoline.

Fig. 636. Tube spliced and wrapped.

4. Cement with vulcanizing cement, two coats. The first coat should dry 20 to 30 minutes, then apply the second coat and let dry two or three hours.

5. Place about a tablespoonful of French talcum in the tube. This is used to dust the inside of the splice to prevent the edges from sticking together when vulcanizing.

6. With the talcum in the tube the ends may be evened up and the ones which have been turned back may be pulled over the other ends. Splicing mandrels may be used here if desired.

7. Secure two blocks of wood ½″ narrower than the tube, but longer than the splice. Place one of these over each splice. It will take three cures of fifteen minutes each to finish the repair.

8. When cured inflate the tube after which the rough edges of the splice may be buffed off on the buffing wheel.

JOB 206. COLD PATCHING.

This method of repairing tubes is not to be recommended for general use. It is well, however, for the student to familiarize himself with the process.

Fig. 637. Stitching down valve patch.

The success of the work depends to a large extent on the proper roughing or sandpapering of the rubber to be joined. Always allow sufficient time for the cement to dry properly before assembling the patch on the tube. Patching cement is, at times, also used for applying reliners.

1. Find the leak. Roughen with sandpaper or rasp.
2. Clean with gasoline, and cement with patching cement.

3. Secure a patch or piece of cured rubber. Prepare same as the tube.
4. Permit cement to dry from ten to fifteen minutes.
5. Place the patch over the injury and rub down good and firm.
6. In the case of a road repair the tube may be put into immediate use.

JOB 207. APPLYING VALVE PATCHES OR PADS.

The best method of repairing breaks in valve patches at the point where the valve stem comes through is to apply a new patch to the tube as described below. . Take all fittings off the valve and force valve back into tube. A hole is cut through the tube at the point where the patch was applied and the valve stem put in. The old valve patch is then repaired by filling the hole as described for large injuries and curing.

1. Buff, with emery cloth, surface of tube to which patch is to be applied.
2. Wash with solvent.
3. Apply two coats of C-35 acid cure cement.
4. First coat should be allowed to dry twenty minutes; second coat, thirty minutes.
5. Apply acid solution to cemented portion of tube and immediately place patch in position.
6. Stitch patch down thoroughly, being careful to secure the edges.
7. Then wrap on the tire last or tube mandrel with strips of cloth and leave it in this position for thirty minutes.
8. Another method of applying patches is to apply C-25 quick cure vulcanizing cement in place of C-35 and curing on hot plate.

JOB 208. REPLACING VALVE STEMS.

1. Around the base of the valve is a fabric reinforcement in the tube. Consequently the valve cannot be pulled out without rupturing the fabric.
2. To replace the valve stem, cut a hole in the tube large enough to remove the old valve stem, and insert the new one through it. After the new valve stem is inserted, repair this hole in the usual manner.

JOB 209. OUTER CASING REPAIRS.

General Rules for the Preparation of Fabric Tires.—Punctures and small holes through the tires, and small fabric breaks can be repaired by the application of a built-up sectional reliner. The size and number of plies in this reliner depends upon the size of the tire and upon the condition of the plies.

Four types of sections are used in the repair of large breaks in fabric tires. They are: quarter section, half section, full section, and inside section. A top section is used, but it will be taken up under the heading, "Tread Cuts and Retreading."

The inside of the tire should be buffed thoroughly before the repair is torn down. After the carcass plies are stepped out the tire will be too flimsy to allow it to be buffed properly.

The **length** of the section is determined by the following general rules, which apply to all types of sections.

1. All plies are stepped down 1″ in the direction around the tire.
2. Two plies are removed in the case of 3″, 3½″, and 4″ tires; and three plies in the 4½″ and 5″ tires, unless the size of the injury warrants a stronger repair, this is, to a large extent, a matter of judgment.
3. A margin of 1½″ is left between the last ply removed and the extreme point of injury.
4. The tread is laid back 1½″ further than the first ply removed.

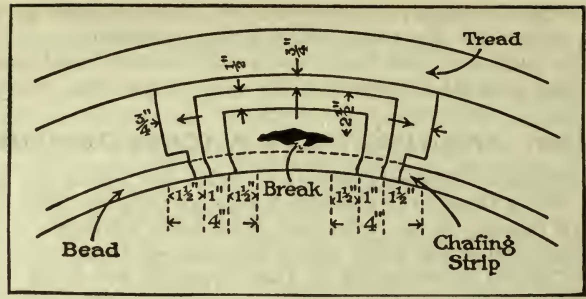


Fig. 638. Diagram of quarter section.

JOB 210. TEARING DOWN QUARTER SECTION.

A quarter section is used in the case of a tire being rim cut or with a broken bead, in 3″, 3½″, and 4″ regular clincher casings. The length of the section is determined by the rules given above. It is necessary to remove only two plies of old fabric.

In the case of a quarter section, the side wall is removed 4″ from the extreme points of injury. The ends are skived. The chafing strip is removed ¾″ inside the point at which the side wall was removed. Remove the top ply, cutting 2½″ outside of the extreme points of the injury and ¾″ below the tread line. Take this ply out to the toe of the bead. Remove the second ply, stepping down 1″ on the ends and ½″ on the tread side. It is also removed to the toe of the bead. Skive the edges of the injury, removing all loose fabric. After repair is ready to buff, the ends of the injury should not touch, and should taper to a feather edge. Buff thoroughly all the exposed outside surface 1″ farther than the longest ply stepped out, and from the toe of the bead to the center of the tread. It is now ready to cement.

Clean with cloth moistened with solvent. Apply three coats of C-16 or C-15 cement as per the following directions for the application of cement. These directions are general and are to be followed in the cementing of all types of repairs:

1. Apply the first coat thin and rub in well. This corresponds to the filler coat in painting.

2. Apply the second coat heavier than the first and smoothly. This is a cover coat.

3. Apply the third and last coat thinner than the second and heavier than the first, and rub in well. This is a finish coat.

4. Allow the first coat to dry from 30 to 60 minutes, the second 30 to 60 minutes, and the last until the cement becomes tacky, which occurs in three to five hours, depending upon the humidity. Cement is not dry until all of the solvent has been evaporated. It is important that cement should not be allowed to dry too long, otherwise an air-cured film will form which may weaken the union.

JOB 211. BUILDING UP THE QUARTER SECTION.

1. Dust and dirt should be removed with a cloth moistened in solvent. All edges of the old fabric should be covered with strips of G-170 ¼″ wide. Fill the hole through the tire with G-170 cushion stock. Apply the first ply of HF-41 frictioned two sides, skim-coated one side, with the skim coated side down, lapping ⅛″ over the old fabric and extending to the toe of the bead.

Apply the second ply, lapping ¾" over the old fabric. This ply is made long enough to extend over the bead, and to extend up the inside of the tire to a point half way between the center of the tread and the tread line.

2. Where the new fabric passes over the bead, it should be trimmed down to make a butt joint with the old fabric. Replace chafing strip with LF-52, lapping it ¼" at the ends. This chafing strip will extend over the bead and 1"

Fig. 639. Quarter section torn down.

inside of the tire. Replace the side wall with G-100, G-105, or G-115. Before the last ply is stitched down on the inside a small patch of HF-41, 1" larger all around than the injury, is placed over it. Cover all edges of the new fabric with strips of G-170.

3. Dust the inside and the outside of the casing lightly with soapstone. Repair is now ready to be cured according to table.

Fig. 640. Stitching down plies in quarter section.

JOB 212. TEARING DOWN FOR HALF SECTION.

1. A half section is built into the tire when the injury is between the bead and the center of the tread. The length of the section is determined by the general rules. It is necessary to remove only two plies of old fabric. When the injury is large enough to warrant the removal of more than two plies, the full section must be built into the tire.

2. Lift the tread and breaker from one end, allowing the tread to hinge at the other. Remove the side wall 4″ from the extreme points of injury. Skive the edges. The chafing strip is removed ¾″ inside the point at which the side wall was removed. Measure back 1½″ from the ends of the section and step out the top ply. The top ply is stepped out 1″ from the tread line on the side opposite the break to the toe of the bead on the same side as break. The second ply is taken out 1″ narrower all around than the first. The ends of the tread at the point where it is cut across the tire should be skived on an angle of 45°. If there is a hole through the tread, all loose gum is trimmed out.

Fig. 641. Inside of casing, illustrating plies laid back to show construction.

The exposed surface on the outside of the tire is buffed. The inside of the tire is buffed from toe to toe of beads and 1" longer on either end than the largest ply taken off; this should be done before the tire is torn down. Follow the general instructions for cementing.

JOB 213. BUILDING UP THE HALF SECTION.

1. When the cement is dry, clean it with a cloth moistened with solvent and cover the outside of the entire exposed surface with G-170, 1/64" gauge. This gauge can be obtained by cutting the 1/32" gauge stock one-half the size of the surface to be covered and stretching 100%, the G-170 extending to within 1½" of the heel of the bead.

2. The hole through the tire is filled with G-170 cushion gum.

3. The first ply is replaced, lapping the edges of the second ply removed ⅛". The second ply is replaced, lapping the edges of the first ply removed ¾". This ply is cut long enough to cover the inside of the tire from bead to bead. At the point where the fabric goes over the bead, it is skived so as to make a butt joint with the old fabric. After this ply is replaced, cover the entire surface of the tread with G-170, 1/32" gauge. The chafing strip is replaced, lapping the old chafing strip ¼" at the end. Replace the side wall with G-100, G-105, or G-115.

4. The tread is then laid down, stitching carefully between the buttons. The "V"-shaped hole where the tread was cut is filled with tread stock higher than the original tread, the new gum is then cut out to match the pattern of the tread. Any holes in the tread are repaired in the same manner.

5. A small patch of HF-41 1" larger all around than the injury is placed over it. The last ply from the outside is carried over the bead and around the inside of the tire to within 1" of the bead on the side opposite the injury.

6. The chafing strip is carried 1" inside the tire. Cover all raw edges of the fabric with G-170. Dust the inside and outside of the tire with soapstone. The tire is now ready to be cured according to table.

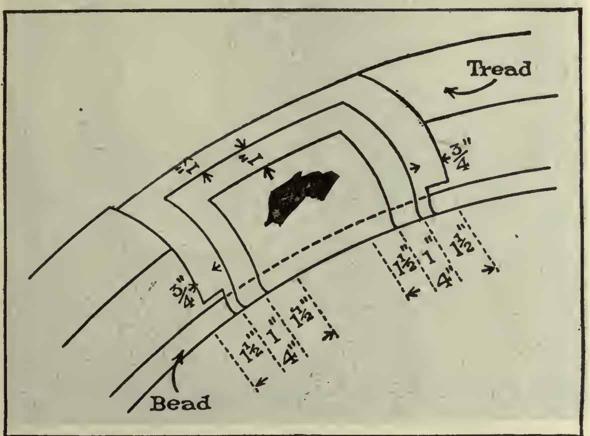


Fig. 642. Diagram of half section.

JOB 214. TEARING DOWN FOR FULL SECTION.

1. A full section is used in the case of a large blow-out or where the blow-out is in a position that it cannot be repaired with a quarter or half section.

2. Two plies are removed from the 3″, 3½″, and 4″ tires, and three from the 4½″ and 5″ tires. This is a general rule that must be varied if the injury is exceptionally large and the fabric around the hole must be removed on account of separation. The length of the section is determined by the general rule.

3. The inside of the tire should be buffed 2″ longer than the longest ply removed.

Fig. 643. Half Section ready to be built up.

4. The tread is laid back the length of the section the same as in the case of a half section.

5. The side wall is removed from both sides of the tire, and both chafing strips are removed. The first ply is stepped out from toe of bead to toe of

bead, and 1½″ inside the point at which the tread was laid back. The other plies are stepped out 1″ shorter on either end than the preceding. All loose fabric and all loose gum is trimmed from the injury. Buff thoroughly all the exposed outside surface of the carcass and underside of tread and cement according to general instructions.

Fig. 644. Showing method of laying in the tread.

JOB 215. BUILDING UP THE FULL SECTION.

1. When the cement is dry, remove any dust with a cloth moistened with solvent. Cover the exposed surface of the tire with G-170, 1/64″ gauge, to within 1½″ of the bead. Replace the old plies with new HF-41, skim coated side down, lapping ⅛″. This applies to the underplies. If the ply taken out is trimmed to the toe of the bead, the ply replaced should be trimmed at the toe, also; that is, the new ply should be trimmed at the same point as that at which the old ply was trimmed. The top ply is cut long enough to cover the outside and inside of the carcass and to lap itself ¾″. The side walls and chafing strips are replaced and the tread is laid back in the same manner as in the half section.

2. The last ply is then stitched over the bead. On the one side it is carried 1½″ up the inside of the tire, and the other end of the ply carried around the inside of the tire to meet it with a lap of ¾″. At the point where the fabric goes over the bead, it is skived so as to make a butt joint with the old fabric. A piece of new fabric is cut large enough to run from toe to toe of the beads and extend 1″ further on either end than the ply brought around the outside. This is stitched down inside the tire over the ply which was

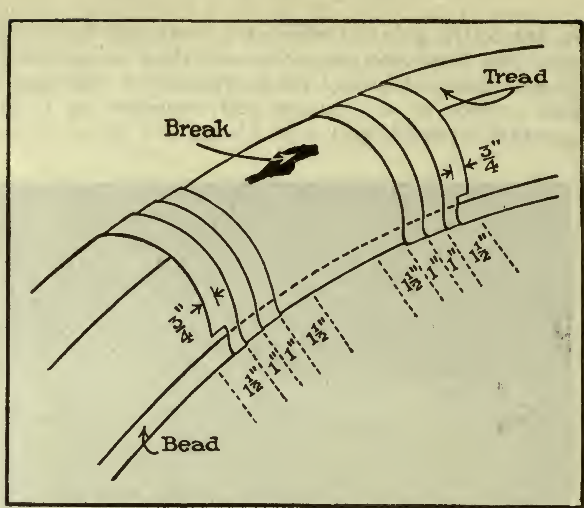


Fig. 645. Diagram of full section.

Fig. 646. Full section ready for building up.

brought around from the outside. All raw edges of new fabric are covered with strips of G-170. Dust the inside and outside of the tire lightly with soapstone. Cure according to instructions.

JOB 216. INSIDE SECTION.

1. Inside sections are made to repair fabric breaks on the inside and almost through the tire, when the injury is small and it is deemed inexpedient to lift the tread. It is not used to make repairs below the tread lines.

2. It replaces the full section for small repairs. Half, or less than half, of the plies are taken out in four or five ply tires, and three in six or seven-ply tires. When two plies are removed, the first ply is taken out 2½″ from the extreme points of injury. When three plies are removed, the first ply is taken out 3½″ from the extreme points. The largest ply is taken out to the toe of the bead and each ply is stepped out 1″ narrower than the first ply. This is buffed and cemented in the regular manner.

Fig. 647. Photo showing inside of tire and method of carrying ply around from outside.

3. The first ply is replaced, lapping ⅛″ all around. No skim coat of G-170 is necessary. All raw edges of fabric should be covered with a narrow strip of G-170. The skim coated side of HF-41 is placed down. All underplies are lapped ⅛″. The last ply replaced is lapped ¾″ and carried to within ½″ of the toe of the bead. One or two over-all plies are placed over the repair running from toe to toe, and extending 1″ over the last ply replaced in the tire. Dust the repair with soapstone and cure according to instructions for full section.

JOB 217. REPAIRING OF CORD TIRES.

The Goodyear Cord Patch is used when the cut or injury in the cord casing is no longer than 3½″ and occurring between the tread lines.

1. Buff the inside of the casing from toe to toe of bead and somewhat wider than the patch to be applied.

2. Trim the loose gum and fabric from the injury so that the edges of the plies do not touch, and the hole is free and open. Taper the hole so that the inside is larger than the outside.

3. Buff the injury thoroughly.

4. Clean with cloth moistened with solvent.

5. Cement outside of repair to be made with C-15 or C-16 vulcanizing cement.

6. Cement the inside of the casing where the cord patch is to be placed with three coats of C-25 vulcanizing cement.

Fig. 648. Showing tread laid back and V-shaped cut in tread.

7. When the cement is thoroughly dry, remove the holland from the gum side of the cord patch and insert the patch using a paddle, stitching down carefully so that the patch is not bridged and no air is trapped. The oval in the patch should be directly over the injury whether the injury is in the center of the tread or not.

8. After the patch has been stitched down into place, trim the protruding edge or edges.

9. Always clean uncured gum side of the patch with a cloth moistened with solvent. If any stock from the holland sticks to the G-180, it can be removed with a rag moistened with water. It is then thoroughly cleaned with solvent, allowed to dry thoroughly and applied.

Fig. 649. Inside of tire, showing construction.

10. After stitching the patch firmly into place, fill up the injury on the outside with G-170 cushion gum up to the top of the breaker strip.

11. The remaining part of the injury should be filled with G-100, G-105, or G-115 tread gum.

12. Repair is ready for cure. See chart for cure for regular sectional repairs.

13. Cord separation, on the inside only, may be taken care of by the Goodyear Cord Patch.

14. Buff thoroughly.

15. Cement with C-25 cement and insert patch over weakened part of carcass.

16. Cure on inside vulcanizer.

Fig. 650. Inside section ready to be built up.

JOB 218. FULL SECTION CORD TIRE.

For extremely large injuries it is necessary to make a full sectional repair. Injuries that occur below the tread line, if they are too large or in such a position that they cannot be repaired with a cord patch, must also be repaired with a section. Cut the tread and breaker strip at point where injury occurs and lay tread back 5″ in both directions.

1. It is necessary to tear out all of the cords in the first group on the inside and outside.

2. These are removed as follows:

3. First layer of cords allows a margin of 1″ on either side of the extreme points of break and from toe to toe of bead.

4. Second ply is to be removed ½″ inside of first ply.

5. Chafing strips and sidewalls should be removed for a distance of ¾″ beyond the point where the cords are removed.

6. The tire is then spread open so as to allow the removal of the cords on the inside.

7. The inside plies run opposite to the outside. These plies are removed the same as the outside. Chafing strips are laid back to the toe of the bead ¾″ farther than the widest ply taken out.

8. Buff the inside of the casing far enough so that a "cross" of cord fabric may be inserted over the injury.

9. Buff the exposed surface of the tire thoroughly.

10. Cement both inside and outside with three coats of C-15 or C-16 vulcanizing cement.

11. Place cushion gum where the old cords have been removed.

Fig. 651. Hole trimmed out with sides tapered.

12. Cushion gum should not be stretched and should be left full $\frac{1}{32}''$ gauge.
13. New plies of cords are then inserted without lapping.
14. The injury is then filled from the outside with G-170 cushion gum.
15. Cushion gum is then placed over the cemented tread surface.
16. The chafing strip is replaced with LF-52 fabric.
17. Side wall rubber is replaced with G-100, G-105 or G-115.
18. The tread is then laid back and stitched down thoroughly.
19. G-170 cushion gum is then placed where the plies have been torn out on the inside.

20. The old plies are replaced with new cord fabric in the same manner as the plies have been replaced on the outside.

21. After the plies are replaced on the inside, the same number of plies of fabric as have been taken out on the inside are inserted, running at right angles to the plies removed and from bead to bead and forming a "cross." This over-all ply or plies is 2" wider than the injury and applied skim coated side down. The under ply of the reinforcement should be made ½" narrower than the outer ply in order to avoid an abrupt change in thickness at the edges.

22. This forms a reinforcement over the injury.

Fig. 652. Showing method of inserting cord patch inside of tire.

23. The section is then cured in the same manner as a fabric tire—in a sectional mold.

24. It may be necessary to cure the section twice because of its length.

25. However, effort should be made to keep the repair short enough so that it may be cured completely with one cure.

Fig. 653. Outside of section ready to be built up.

26. All cushion gum, G-170, should be used $\frac{1}{32}''$ gauge.

27. Nominal size airbags are usually too small in cross section for use in cord tires. Be careful in selecting your airbag for cord tire sectional work. For example, a 4½″ sectional airbag will fit a 4″ cord tire better than a 4″ sectional airbag.

JOB 219. CORD TIRE FULL SECTION.

1. This method is used when the 45° repair is too long.

2. Lay back tread as described for fabric tire full sectional repair. The length of tread in inches to be laid back will be 6+ (total length of injury in inches) + 2 (number of plies removed from the outside — 1). The center of the section of tread laid back should correspond to the center of the break.

3. Remove the chafing strip and side walls.

4. The popular sizes of cord tires are listed below with the number of plies in each size.

30 x 3½	4 plies	33 x 4½	6 plies
32 x 3½	6 plies	34 x 4½	8 plies
33 x 4	6 plies	35 x 5	8 plies
34 x 4	6 plies	37 x 5	8 plies
32 x 4½	6 plies		

5. Repairs of this kind may be divided in two classes: first where the break occurs between the tread lines on the top of the tire, second where the break occurs between the bead and tread line.

6. Repairs of the first type:

7. Remove one-half the total number of plies from the outside of the tire. In eight-ply tires, first ply should be cut 4½″ from the extreme points of the injury. For six-ply this distance will be 3½″ and for four-ply 2½″. The outer ply in all cases is cut out around the bead to the toe and the ply beneath is taken out to within 1″ of the heel. When more than two plies are removed the plies are stepped down 1″.

8. Loose fabric and rubber is trimmed out of the break and the repair is then buffed, the inside of the tire being buffed for a distance of 4″ at each end beyond the point where the outer ply was cut.

9. Cement according to general directions both inside and out.

10. Build up the inside of the repair first as follows:

11. Stitch in a ply of CF-44 skim coated side down and cords running in opposite direction to cords in tire. This ply should extend ½″ on each side of the points at which the outer ply was cut and to within ½″ of the toe of the bead. Over this ply is placed another ply 2″ longer than the first ply and extending to the toe of the bead.

Fig. 654. Inside of section ready to be built up.

Fig. 655. Inside of section built up with cross.

12. This ply is only stretched down to within 2½″ from the bead.

13. Fill in the hole through the carcass from the outside with G-170.

14. Build up the outside by covering the cemented surface with a ply of G-170 $\frac{1}{32}$″ gauge. Replace the plies cut out with CF-44 skim coated side down, cords running in same direction as the original plies. New plies should overlap ¾″ and cords should have the same direction as those of plies replaced. The last ply replaced should be cut long enough to extend around the bead on each side and 1½″ above the toe of the bead on the inside of the tire. After this is stitched down, the inside reinforcing ply should be stitched over it.

15. Where the ply goes around the bead it should lap ¾″ as on the rest of the repair.

16. Replace the side walls and chafing strips, lay back the tread and fill the hole with G-105 tread stock. Dust with soapstone and cure according to directions for full section in sectional mold.

17. Repairs of the second type:

18. In this kind of repair where the break occurs between the tread line and the bead it is necessary to lay back the tread and cut off the chafing strips and side wall. Remove one-fourth of the total number of plies from the outside and one-fourth from the inside. The plies are taken out from the outside the same manner as described for outside repair and the plies on the

Fig. 656. Section ready to be built up.

inside are stepped out from toe to toe and are 1" shorter than the largest ply taken off the outside. The remaining plies are stepped down 1".

19. Trim out loose rubber in the break and cement.

20. Replace the plies in the manner described for the first type of repair, placing a skim coat of G-170 both inside and out.

21. Put one reinforcing ply on the inside with cords running in the opposite direction to cords in last ply replaced.

22. This ply should be stitched down over the last ply brought around for the outside of the repair.

23. Cure the repair in sectional mold according to directions for full sectional cure as given in the chart.

Fig. 657. Section built up before laying back tread.

JOB 220. WIDTH OF BREAKER.

Fabric Tires		Cord Tires	
Size Tire	Width of Breaker	Size Tire	Width of Breaker
3"	2¼"	3½"	3"
3½"	2½"	4"	3½"
4"	2¾"	4½"	4"
4½"	3¼"	5"	4½"
5"	4"	Splices ¼"	Splices not closer than 10"

JOB 221. REPAIRING TREAD CUTS.

1. Tread cuts should be repaired at once so that sand and moisture will not work into the tire and cause separation.

2. Bevel out injury down to the carcass so that it is free and open. Buff thoroughly. Clean with cloth moistened with solvent. Cement according to directions.

3. When thoroughly dry, fill injury with layers of G-100, G-105, or G-115, depending upon the color of the rubber in the tread of the tire.

4. The injury is built up higher than the original tread. The original tread pattern is then cut into the raw stock.

5. Cure for tread cuts should be taken from the chart.

6. In repairing the tread cut it is essential that the fabric directly under the cut is free from foreign matter such as dirt and moisture.

7. If, on examination, it is found that the fabric is water-soaked and full of dirt, remove the first layer of fabric on the outside in the form of a small, square patch.

8. In building up, this should be covered with G-170 cushion gum.

9. Place a piece of HF-41, 1/8″ larger than the piece taken out, in the square made above. Place G-170 gum over the ply placed in position.

10. Then fill the cut of the tread in the same manner as described above.

11. In case of mud boils or sand blisters, cut the blister open and remove all of the loose rubber from the carcass. Buff thoroughly.

12. In case more than one ply is removed, the plies are stepped down 1″.

13. Then replace with HF-41 fabric, allowing 1/8″ lap on the under plies and 3/4″ lap on the last ply.

14. Then place an inside reliner extending from toe to toe of the bead of approximately 1″ more in width than the largest ply of new fabric replaced on the outside.

15. Fill in the cut on the outside.

16. Dust with soapstone. Cure repair according to chart.

Fig. 658. Filling in the Injury.

JOB 222. PRESERVING THE TREAD.

1. When vulcanizing a section in a non-skid tire it is not necessary to disfigure the tire by a section on which the tread design is imperfect, due to the old design being flattened out in curing.

2. The design may be preserved by the use of a stiff paste, made of soapstone and water. When soapstone is used the tread pattern is cut in the new rubber before the cure.

3. Another method of preserving the design is to make up a matrix or

negative pad from one ply of LF-52 and two plies of $\frac{1}{16}''$ gauge tread gum. The pad should be wide enough to cover the width of the tread and long enough to extend about 1″ beyond either end of the molds with which it is to be used.

4. Soapstone the pad freely and fit it over a section of the tread that is in good condition. Insert a sectional air bag. Clamp the tire in the mold and cure. (See table.)

Fig. 659. All-Weather Negative Pad.

5. The result will be a perfect mold of the tread pattern.

6. When the repair is ready to vulcanize soapstone the raw section of the tire, then take the pad and apply C-35 cement at the edges. Fit the pad over the section; the cement will hold it in place. Cure the repair as recommended.

JOB 223. REPAIRING SCRAPED SIDE WALLS.

1. Side wall repairs are of three kinds: (1) Side wall rubber may be injured and no plies damaged; (2) the top ply may be injured and plies cut; (3) the side wall rubber may be chafed and several plies worn through for the entire circumference of the tire.

2. When the side wall rubber alone is injured, the old rubber is trimmed away and the exposed surface is buffed and cemented. A new side wall is inserted, replacing the old rubber.

3. When the top ply has been cut through, it is often necessary to replace this cut ply by a new ply which is built in, in a manner similar to a quarter

section. The side wall and chafing strip are removed and the ply is taken out to the tread line. The ply of fabric is replaced by a new fabric extending around the bead of the tire to a point half way between the center of the tread and the tread line on the same side as the chafed side of the tire.

4. When the plies have been cut locally through only a few plies of fabric, it is often more expedient to reinforce the inside of the casing with a sectional reliner, trimming out the injury and filling in with new side wall rubber. These repairs may be cured in either a sectional mold or like a retread by inserting the coil and curing it in a kettle. Local repairs that have a sectional reliner are cured according to the chart.

Fig. 660. Scraped side wall.

JOB 224. RETREADING.

1. Remove old tread rubber and breaker strip from tread line to tread line.

2. Fig. 662 shows tire ready for retreading.

3. Buff exposed surface and cement with three coats of C-15 or C-16 vulcanizing cement, according to directions.

4. Sometimes when the tire has been run too long it will be found that one or two outer plies have been so damaged by water and dirt working through the tread that they must be removed. In this case the injured ply or plies should be stepped out and replaced with new fabric. To do this the plies are stepped out on each side of the broken fabric, keeping as close as possible in order to stay above the flex points. Room should be allowed for a ¾″ step

Fig. 661. Scraped side wall, one or more plies of fabric worn through.

if the under ply is removed. In building up the HF-41 is applied directly to the cemented surface skim coated side down. A ½″ lap is made on the under ply and a ¾″ lap on the outer ply.

5. G-100, G-105, G-115 is used when applying a plain laid-up tread. The gauge should be the same as the corresponding camel back for the same size tire. (See chart for proper sizes and widths). When this tread is laid up and thoroughly stitched, all air being removed, it is placed on the carcass directly over the breaker strip. It is trimmed at the tread line.

6. Camel back may be used in place of the built-up tread.

7. In some cases it is necessary to put a section in the tire before it is retreaded. In this case remove the old tread rubber, breaker and cushion. Trim out the repair and rebuild section in the usual manner with the exception of applying the tread.

8. This section should be given a semi-cure.

9. This cure is sufficient to shape the beads and side wall rubber of the section.

10. The casing is then buffed and cemented and the retread applied in the usual manner.

11. Goodyear Camel Back is furnished to eliminate the plying up of ordinary tread rubber for retreading work.

12. Camel Back is applied in the same manner as the built-up tread.

Fig. 662. Tire Buffed and ready for retreading.

JOB 225. BUILDING UP THE RETREAD.

1. When cement is thoroughly dry, apply one ply of G-170 cushion gum $\frac{1}{32}''$ gauge. This cushion gum should extend to within ½″ of the edges of the cemented surface.

2. Breakers should be cut "on the straight" for fabric tires and on the bias for cord tires.

3. Apply breaker strip. (See chart for width of breaker strip for various sized tires.)

4. In applying semi-cured retread bands a layer of $\frac{1}{16}''$ gauge tread gum is placed over the breaker strip extending from tread line to tread line.

5. The semi-cured retread band is thoroughly buffed and cemented with three coats of C-15 or C-16 vulcanizing cement.

6. When cement is thoroughly dry the band is placed on the tire.

7. A piece of clean muslin or holland should be placed over the cover-stock before the band is applied. This will eliminate the possibility of the tread band sticking to the carcass before it is centered.

8. When band is centered, remove the muslin or holland and stitch well, stitching from the center out. Stitch between the buttoms.

9. Be careful that you have removed all air blisters between the cover-stock and the carcass proper.

10. After stitching down the band, the edges should be trimmed ½″ above the undercover line in 3″, 3½″, and 4″ tires. Trim off ¾″ above the under tread line in 4½″ and 5″ tires.

11. Retread is ready for cure.

Fig. 663. Successive steps in building up retread, showing buffed surface, cushion, breaker, under-cover and semi-cured retread band.

JOB 226. CURING THE RETREAD.

Kettle Cure.—Insert steel coil of sufficient size to keep the toe of the beads 1½″ apart.

1. Make a thick paste of soapstone and water and fill the cavities in the tread design if semi-cured band is used. The paste keeps the tread design from flattening out under pressure.

2. Cover the outside of the casing to just below the tread line with a heavy jacket of cotton canvas, or muslin, cut on the bias.

3. Then wrap the tire with cotton canvas strips approximately 2″ in width. This should be wrapped around with a 1″ lap. Wrap twice around, reversing the direction the second time around.

4. Use extreme pressure in wrapping the casing.

5. Use length and temperature of cure specified on chart.

6. When applying the plain tread, the entire surface of the tread is dusted with soapstone, the coil is inserted, and a heavy jacket of cotton canvas or muslin is applied, covering the raw stock. The tire is then wrapped with strips of cotton canvas as when retreading with a semi-cured band. The tire is now ready for cure.

JOB 227. THIRD CIRCLE RETREADING.

1. For one-third circle retreaders camel back stock or built-up tread gum is applied.

2. Care must be taken in curing by one-third circle retread methods to get the best results and minimum of defects.

3. A sand bag is used in curing retreads in one-third circle retreading.

Fig. 664. Laying up a tread.

The pressure is secured by means of clamps and a pressure bar. The sand bag should fit snugly in the casing and should be just as long as the mold. It should be of sufficient diameter to assure a good pressure on the side walls.

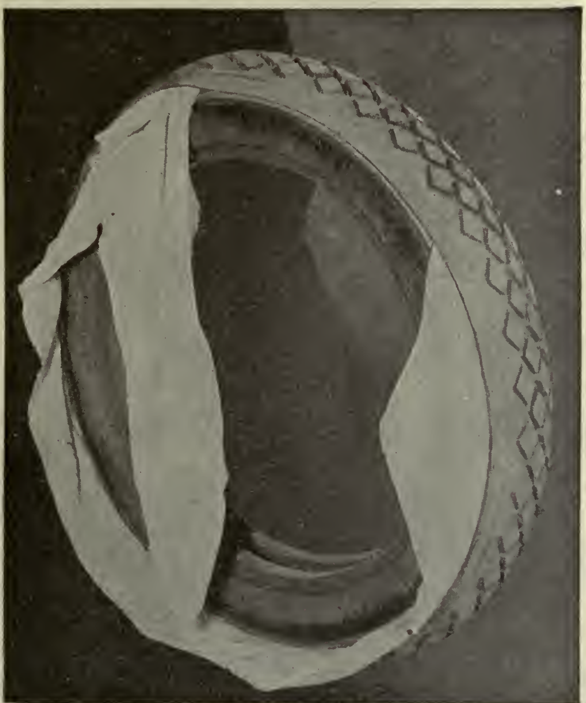


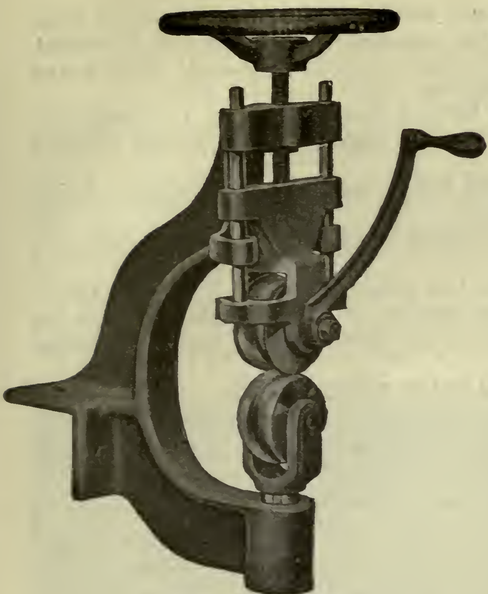
Fig. 665. Photo showing method of putting band on tire with muslin.

Fig. 666. Section of casing cut down to show coil, soapstone and method of wrapping.

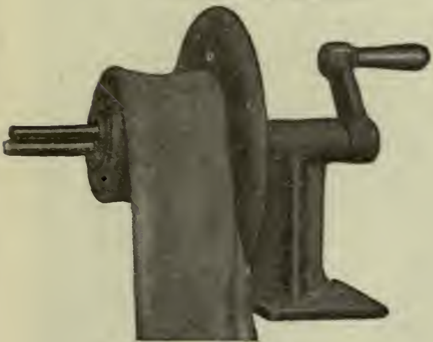
4. Care should be taken that the pressure bar used on top of the sand bag is not bent or out of shape.

5. If the pressure bar is out of shape, flat spots will occur on the tread surface between the points directly under the clamps. The pressure bar should not be too large and stiff, otherwise, the pressure will not be distributed evenly and light spots may result. The clamps should be tightened down gradually

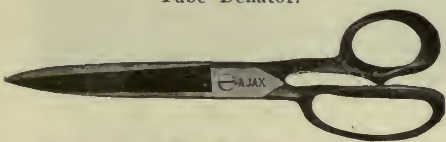
Fig. 667. Third circle retreader.



Tread Rolling Machine.



Tube Deflator.



Shears.

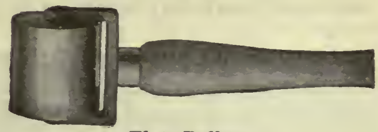
Fabric Knife.

Hand Tube Roughing Brush.

Rubber Knife.

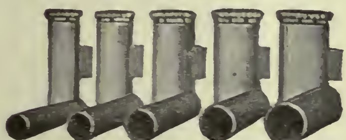
Concave Roller.

Wire Roughing Brush.



Flat Roller.

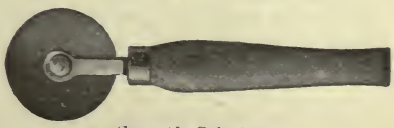
Tread Gauge.



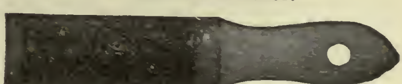
Inner Tubes Splicing Mandrels.

Awl.

Corrugated Stitcher.



Smooth Stitcher.



Hard Casing Roughing Brush.

Fig. 668.

from the center of the mold out, so that no air is trapped, which would cause defects in tread. Tighten clamps about ten minutes after the cure is started.

6. The tire should be kept in an upright position so that the tread design or ribs are centered evenly around the tire.

7. The edges of the tread gum, after it is applied to the tire, should be skived and stitched down to a thin feather edge so that a perfect union is insured without excessive overflow.

8. Be sure to examine the casing during the cure for air blisters at the ends of the section that is being cured.

9. If these blisters appear, they should be opened at once by means of a sharp awl.

10. Sand used in sand bags should be screened through a 20 mesh sieve.

11. It is advisable to use a small amount of fine flake graphite with the sand to eliminate any bunching or caking and assist in giving uniform pressure.

JOB 228. RETREADING CORD TIRES.

Retread the cord tire in the same manner as the fabric tire.

After the old tread is removed, inspect the tire carefully. The tire should not be retreaded if it has ply separation.

The building up and curing is the same as for fabric tires.

CHAPTER 17

GARAGE SHOP REPAIR METHODS

JOB 229. LIFTING AN ENGINE FROM A CAR.

The use of a crane, a heavy block and tackle, or chain block is essential to lifting a motor from a car. Various types of cranes are in use. Where many cars are handled in a certain location the traveling crane, mounted overhead in such manner that the chain block may be run to any point over a considerable area, is best. The crane mounted on the single track is rather limited in its service. The double track overhead crane which permits of side to side motion as well as movement along the track is very good.

The floor crane which is so arranged that it may be run under the front axle of the car to lift out or replace the motor is ideal for the smaller garages. Fig. 669 shows the Franklin crane of the portable type being used to replace

Fig. 669. Lifting an Engine with a Portable Crane.

the six-cylinder engine in a Reo car frame. The particular advantage of this type of crane is the ease with which a heavy motor may be lifted out and then moved to any desired position. When in use for lifting, the front wheels are locked under the frame to prevent the crane moving. Throwing the handle controlling these wheels forward releases the wheels and permits of the crane and load being moved about the floor.

The floor crane is also used for lifting the body or frame away from the rear axle. Care must be used in making the hitch to prevent the top or body being injured.

In making a hitch on an engine or other load for lifting make very certain

it is secure and safe. Ropes and wire are to be avoided for this type of work Special clamps or a good square link chain are safer and better.

JOB 230. USING A GARAGE PRESS.

The development of the automotive trades has led to the development of special labor and time saving equipment. The arbor press which is best fitted for limited machine shop work is not always best fitted for the wide range of work met with in the garage. The special garage presses such as the Weaver, shown in Fig. 670, are better suited.

Fig. 670. Using a Garage Press to press in ball cup.

In the use of a press of this nature several points must be kept in mind. Owing to the tremenduous pressure the work must be handled carefully to avoid any damage.

1. Adjust the table to accommodate the work.
2. Make certain that the work is to receive the pressure at the correct point.
3. Do not attempt to press while work is resting on makeshift supports.
4. Do not apply pressure with the spindle or shaft being pressed setting at an angle.
5. Where bushings or gears are being pressed on make certain the parts are entering properly.
6. It is a good plan to round the ends or edges of the bushings just a trifle to insure their pressing properly and not grabbing on the side of the retainer.
7. Where work is too long to enter with the press setting on the floor, it may be blocked up or even be operated while laid on the side.

TAPS AND DIES.

In order that the student may recognize the various sizes and kinds of threads it is necessary for him to spend some time in studying them. While there are still a number of special threads in use on certain machines, standardization is along the lines of four only.

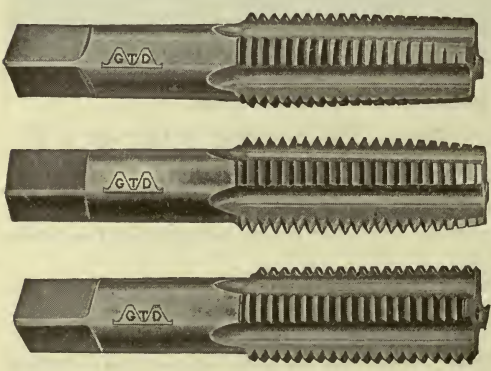


Fig. 671. Taper, Plug and Bottoming Taps.

U. S. S.—This is the abbreviation for United States Standard thread. This thread is a V thread with a flat edge, or an edge which just fails of reaching a point. It is used in all manner of machinery and equipment. In automotive work it is used more for studs which are set in soft metal such as bronze or aluminum or cast iron. Bolts with this thread are used for fastening on the

body, bolting on fenders, and splash guards, and certain other types of work about a car.

S. A. E.—This is the abbreviation for the thread standardized by the Society of Automotive Engineers for use in construction and assembly of most parts about the automobile. The thread is a V thread similar to the U. S. S. but will run finer for the same size of bolt. The student will learn to recognize the difference between these two threads very quickly. It is only the rankest amateur who will attempt to force an improper nut onto a bolt. This thread was formerly known as the A. L. A. M.

Stove Bolt Threads.—This is the third thread commonly found about the

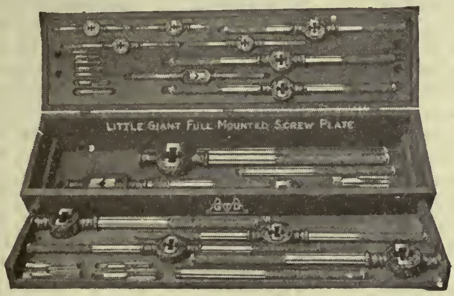
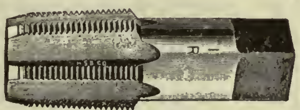


Fig. 672. Thread Dies.

automobile. Its use is confined to rough work such as bolting mud guards and splash pans to the frame or to each other. The thread is still coarser than the U. S. S.

Pipe Threads—This is a thread used for plugs and certain gasoline and water fittings. The ½″ spark plug is fitted with ½″ pipe threads which, being on a taper of ¾″ per foot, give a wedging action as they are screwed into the cylinder head. The ⅛″ and the ¼″ are favorite pipe plugs, used for plugging holes in housings provided for filling the part with grease or oil. Pet cocks are ordinarily pipe threads. The pipe thread is a fine thread and may be recognized by the taper. Since pipe is measured on the inside the student will find a ½″ pipe tap quite a bit larger than a ½″ bolt tap and similarly with other sizes.

Depth of Thread.—A full depth of thread in a nut is only five per cent



Tapered

Fig. 673. Pipe Taps.

stronger than a 75 per cent thread. However the work of tapping it is three times as great.

A common nut drilled out so that only a 50 per cent thread is available when tapped will hold quite well, in fact it is claimed to break the bolt in most cases before stripping.

A 75 per cent thread is much more economical in tapping and yields a fine margin of safety, this being given as 2 to 1.

JOB 231. USING TAPS.

Cutting screw threads with the hand taps is not a difficult piece of work. The beginner must learn, however, to recognize by the feel of the strain on the tap the manner in which the work is being done. In the use of small taps

TAP DRILL SIZES—75% Depth Thread
U. S. F. and S. A. E. Standard

Tap Size	Th'ds per in.	Diam. Hole	Drill	Tap Size	Th'ds per in.	Diam. Hole	Drill	Tap Size	Th'ds per in.	Diam. Hole	Drill
1/16	72	.049	3/64	1/4	32	.220	2	7/8	14*	.805	13/16
† 1/16	64	.047	3/64	1/4	28*	.215	3	7/8	12	.794	51/64
1/16	60	.046	56	1/4	27	.214	3	† 7/8	9	.767	49/64
5/64	72	.065	52	1/4	24	.209	4	15/16	12	.856	55/64
5/64	64	.063	1/16	† 1/4	20	.201	7	† 15/16	9	.829	53/64
† 5/64	60	.062	1/16	5/16	32	.282	9/32	1	27	.964	31/32
5/64	56	.061	53	5/16	27	.276	J	1	14*	.930	15/16
3/32	60	.077	5/64	5/16	24*	.272	I	1	12	.919	59/64
3/32	56	.076	48	5/16	20	.264	17/64	† 1	8	.878	7/8
† 3/32	50	.074	49	† 5/16	18	.258	F.	1 1/16	8	.941	15/16
3/32	48	.073	49	3/8	27	.339	R	1 1/8	12*	1.044	1 3/64
7/64	56	.092	43	3/8	24*	.334	Q	† 1 1/8	7	.986	63/64
7/64	50	.090	43	3/8	20	.326	21/64	1 3/16	7	1.048	1 3/64
† 7/64	48	.089	43	† 3/8	16	.314	5/16	1 1/4	12*	1.169	1 11/64
1/8	48	.105	37	7/16	27	.401	Y	† 1 1/4	7	1.111	1 7/64
† 1/8	40	.101	39	7/16	24	.397	X	1 5/16	7	1.173	1 11/64
1/8	36	.098	40	7/16	20*	.389	W	1 3/8	12*	1.294	1 19/64
1/8	32	.095	3/32	† 7/16	14	.368	U	† 1 3/8	6	1.213	1 7/32
† 9/64	40	.116	32	1/2	27	.464	15/32	1 1/2	12*	1.419	1 27/64
9/64	36	.114	33	1/2	24	.460	29/64	† 1 1/2	6	1.338	1 11/32
9/64	32	.110	35	1/2	20*	.451	29/64	† 1 5/8	5 1/2	1.448	1 29/64
5/32	40	.132	30	† 1/2	13	.425	27/64	† 1 3/4	5	1.555	1 9/16
† 5/32	36	.129	30	1/2	12	.419	27/64	† 1 7/8	5	1.680	1 11/16
5/32	32	.126	1/8	9/16	27	.526	17/32	† 2	4 1/2	1.783	1 25/32
11/64	36	.145	27	9/16	18*	.508	1/2	† 2 1/8	4 1/2	1.909	1 29/32
† 11/64	32	.141	28	† 9/16	12	.481	31/64	† 2 1/4	4 1/2	2.034	2 1/32
3/16	36	.161	20	5/8	27	.589	15 M/M	† 2 3/8	4	2.131	2 1/8
3/16	32	.157	22	5/8	18*	.571	14.5 M/M	† 2 1/2	4	2.256	2 1/4
3/16	30	.155	23	5/8	12	.544	35/64	† 2 5/8	4	2.381	2 3/8
† 3/16	24	.147	26	† 5/8	11	.536	17/32	† 2 3/4	4	2.506	2 1/2
13/64	32	.173	17	11/16	16*	.627	5/8	† 2 7/8	3 1/2	2.597	2 19/32
13/64	30	.171	11/64	† 11/16	11	.599	19/32	† 3	3 1/2	2.722	2 23/32
† 13/64	24	.163	20	3/4	27	.714	23/32	† 3 1/8	3 1/2	2.847	2 27/32
7/32	32	.188	13	3/4	16*	.689	11/16	† 3 1/4	3 1/2	2.972	2 31/32
7/32	28	.184	14	3/4	12	.669	17 M/M	† 3 3/8	3 1/4	3.075	3 1/16
† 7/32	24	.178	16	† 3/4	10	.653	21/32	† 3 1/2	3 1/4	3.200	3 3/16
15/64	32	.204	6	13/16	12	.731	47/64	† 3 5/8	3 1/4	3.325	3 5/16
15/64	28	.200	8	† 13/16	10	.715	23/32	† 3 3/4	3	3.425	3 7/16
† 15/64	24	.194	10	7/8	27	.839	27/32	† 3 7/8	3	3.550	3 9/16
				7/8	18*	.821	53/64	† 4	3	3.675	3 11/16

*S. A. E. Standard †U. S. Standard

particularly is this true. A bit too heavy a strain on the small tap will cause it to twist and spring; the expert mechanic will detect this action immediately but the apprentice may continue turning the tap holder and attempt to force the tap to turn with the result that it is broken off in the nut or hole. The correct procedure when the tap shows signs of twisting is to carefully back it

out and clear out the cuttings. The general method of proceeding in the use of taps is as follows:

1. Select the tap needed for the piece of work at hand.

2. Determine the size drill needed for the blank hole. This may be determined from the table of tap and drill sizes, or by measuring the diameter of the bottom of the taper tap.

3. Drill the hole a bit deeper than the threads are expected to go, if the work permits this.

4. Start the taper tap first and run this as far as it will go without striking the bottom of the drill hole. Keep the tap working freely. Use oil for steel or iron. Oil is not necessary on brass or cast iron.

5. Follow the taper tap with the plug tap.

6. Follow the plug tap with the bottoming tap if threads are to be run to the bottom of the drilled hole.

7. It will be found that the chips and cuttings must be removed from the hole as the work progresses.

JOB 232. USING DIES.

Dies are made either in one piece or adjustable. The latter are the better type since the thread may be made a bit above or below standard to fit special cases. This feature allows of some compensation for wear of the dies and also permits of their being reground. The setting of the dies from standard size should not be done, however, unless the reason is a very good one as it is likely to put unusual strains on the cutting edges. In using dies on steel or iron plenty of oil must be used. Lard oil is recommended, but failing this use machine oil.

1. Learn first the exact die required to cut the thread needed. Make certain that the diameter of the bolt is known and the number of threads per inch. Select the die bearing these figures stamped on it.

2. Start the die on the bolt properly. Dies are made with the first few threads relieved to permit of starting the work with the least effort. This provision also allows the work to proceed gradually, each thread or tooth cutting a bit deeper than the one preceding it. Dies are also provided with a guide which is a free fit over the end of the bolt or rod. This insures the threads being started and kept true.

3. Avoid starting the die with the finishing face first. Where it is necessary to cut threads very close to a bolt head the die should be started correctly and run on as far as possible, after which it is removed and the finishing face started on first. This arrangement permits of the die being started correctly and prevents such a great strain on the finishing threads or teeth.

FORGING.

Practically all modern garages are equipped with a forge. This is not with the idea of making new parts but rather with the idea of facilitating repairs. The automobile is constructed with many parts more or less inaccessible. Some special tool or appliance may be needed in just one instance or to do one particular piece of work. While it may take quite a bit of work to forge out this special tool, it is a saving of time and expense in the end. In other cases a small part may need to be heated for bending, or for straightening. Certain parts from wrecked cars as for instance front axles may need to be heated in the forge to permit of proper straightening. The forge is not used a great deal for the welding about the garage. The oxygen-acetylene process is far better suited.

The student should do enough forging that he may feel confident to

proceed with the making of punches, chisels, and other special tools and appliances.

Carbon steels are susceptible to hardening and tempering. All tools and certain parts of the automobile are made from carbon steel or similar tool steel. Files are a high carbon tool steel, and while they may be forged into a certain shape for use as tools for certain work their carbon content is too great for work requiring much spring.

JOB 233. BUILDING A FORGE FIRE.

Just as in all other classes of work, so it is in forging. Certain fundamental operations or processes are necessary to success. One of the most important is ability to control the fire properly. The following instruction will

Fig. 674. Forge.

clear up many points in the mind of the student as to the proper method of building and maintaining the forge fire. Hand forges are in use more largely than the power blast for garage work.

1. Owing to the fact that a number of men have access to the same forge it is sometimes difficult to maintain it in good condition. The first step on attempting to start a fire is to remove all the coke left from the previous fire. Coke is iron grey in color. light in weight and clean to handle. It is formed by burning all smoke and gas from green coal. Lay the coke to the side or place it in a bucket.

2. Level off the cinders remaining on the hearth. Clean any cinders away from the center of the hearth leaving the center hollowed out down to the tuyere iron. This hollowed space should be about the size of an ordinary wash basin. The tuyere iron is in the center of the forge through which the air blast is forced into the fire, and must show at the bottom of the hollowed space.

3. Make certain the blast is working properly by running the fan. It may be necessary to clean out the ash pit under the tuyere iron, for which a trap door is provided at the bottom of the pit.

4. Place the kindling for the fire. This may be paper and short lengths of kindling wood. Oil soaked rags are sometimes used.

5. Light the kindling, and place on enough blast to get it blazing smartly.

6. Cover the burning kindling with the coke which was saved for this purpose. Keep the blast going and in a few minutes the coke will be glowing white hot.

7. Cover all of the glowing coke which has been heaped to a mound over the center of the hearth, excepting the very top and center with green coal, which is a good grade of smithing coal that has been dampened with water until it will pack. Leave the center open to allow the blast and smoke to come out. Use the shovel to pack the green coal tight around the sides of the mound of glowing coke.

8. The work may now proceed. The green coal is gradually dried out and coked up. By the time the center of the fire has burned out the green coal, with which it was packed, will be converted into coke to replenish the fire. At this point the smith pulls in the coke and thus replenishes the fire, which is again protected with a layer of green coal packed all around its base and open only on top.

9. When inserting the work into the fire care is used not to destroy the shape of the fire.

10 It is useless to attempt work until coke is available for heating the material. If the coke is not at hand in proper quantities, time will be saved by starting the fire and burning some of the green coal into coke.

11 It is useless to attempt work with a fire which has green coal in it, or in one which has cinders mixed with the coke.

12. Keep the hearth leveled off and packed down hard with cinders. They will not burn, but serve as a fire protection to the forge. They also serve to form the basin in which the fire is held. Any surplus of cinders other than those needed for the above purpose should be removed from the hearth. Do not permit the cinder bed on the hearth to be dug up or become mixed with green coal.

13. Do not use the forge for a receptacle for tools. The hammer should lie on the anvil when not in use. The tongs should be kept on a rack, and the hardie by the anvil. The rake, poker and shovel may be laid on the nicely leveled hearth provided the forge is large enough, otherwise keep them on a rack.

14. Keep the space about the forge neat and clean.

JOB 234. FORGING HAND TOOLS.

Cold chisels, cape chisels, gouges, punches, drifts, cotterkey extractors, etc., are hand tools readily forged by the beginner. After some experience, he may confidently attempt the more advanced problems of socket wrenches, end wrenches, and the many problems of that nature. Bearing scrapers are readily forged either from new tool steel or from old files. Old files are also adapted to forging into punches and screwdriver blades.

In attempting to forge out any tools keep the following suggestions in mind:

1. Select stock suitable to the work. Cold rolled or mild steel cannot be hardened nor tempered. Tool steel may be secured from the supply houses.

2. With the stock cut to the proper length, fit a pair of tongs to the work. A link over the end of the tong handles will be of great aid in holding the work properly.

3. Heating tool steel is an operation which requires care. The proper forging heat is just below the white heat and while the steel is in the yellow heat. Forging while white hot will cause certain steels to crumble under the hammer.

4. Reheat the piece of work before the heat has dropped to a dull red.

5. When approaching the final steps of the forging heat, care must be used not to go above the hardening heat which is a so-called cherry red. At this heat the steel works nicely. Forging while red gives smooth surfaces.

6. When drawing out any work, as the work on the punch would require, do not attempt to draw the work while keeping it round. Forge the work square and keep it square until approximately the right length has been secured. The next step is to forge the punch to an octagonal shape, and the final step in the process is to forge the eight corners into sixteen and remove any trifling irregularities. Attempting to draw out a piece of steel or iron while retaining the circular form will result in a split piece of work.

7. Move the work under the hammer and not the hammer over the work.

8. Skill comes with practice.

9. Do not attempt to handle two pieces of work at one time. Disaster will follow.

10. If white starlike sparks are seen coming from the fire, steel or iron is being burned. Just as a piece of steel reaches the welding point it gives off a few sparks. Continued heating above that point will result in a badly burned piece of work. Iron may be forged at that temperature, but tool steel may not.

11. Be careful not to miss the work, or the hammer will rebound from the anvil with great force. Standing well over the anvil the hammer may strike the workman in the face doing serious injury.

JOB 235. HARDENING AND TEMPERING.

After a piece of tool steel has been forged to the proper shape for the desired work or use, it is essential that it be hardened and tempered to withstand the demands made upon it. A cold chisel must have the cutting edge hardened and tempered. A punch must have the small end properly heat treated. Bearing scrapers, screw drivers and wrenches require varying treatments to insure their proper standing up to the work.

Several methods are in use for hardening tools and likewise for drawing the temper. The student will understand that tempering may not be done without the hardening having first been accomplished. The two processes are separate and may not as a rule be accomplished simultaneously. Where special methods of heat treating are in use the single operation may finish the work, but in the tempering of hand tools at the forge hardening to the full degree is the first step. This full degree of hardness is then tempered to the point necessary for the use the tool is to be put to.

Hardening.—After the tool has been forged to the proper shape it is replaced in the fire and heated slowly to a cherry red. A cherry red is about 1400° Fahrenheit and may be recognized as a heat lying between a red and yellow. Experience with the steel at hand will give the correct heat for hardening. When the tool has reached the proper temperature it is dipped into cold water, as much of the tool being inserted as is to be hardened. In the case of a cold chisel or punch about 1½″ is correct. Allow this point to remain in the water until cold. When removed from the water the point should hold the water for a short time before it dries away.

The point is now hardened. The heat remaining in the tool will be sufficient to draw the temper. With a piece of sandpaper or emery cloth polish the point of the chisel or punch until it shows bright. As the heat draws from

the body of the tool to the point, colors will appear on the polished surface of the tool which indicate with fair accuracy the degree of hardness remaining, or the temper of the tool. When the proper color appears plunge the entire tool into the water. The chart gives the colors and the corresponding temperature, and notes a few tools with their corresponding colors and tempers.

In case the tool is to receive the same temper all over, it is first heated properly and thoroughly hardened, the entire tool being cooled in the water bath. To draw the temper the outer surface of the tool is first polished and is then heated gradually over a piece of sheet metal over the forge fire. A gas flame may be played directly on the surface of the tool to draw the temper. The colors should be watched carefully and when the proper one is reached the entire tool is plunged into the water.

Tempering Chart.

Light straw	430 degrees	Lathe tools.
Straw	450 degrees	
Dark Straw	470 degrees	
Light Brown	490 degrees	Milling cutters, taps, dies, and reamers.
Dark Brown	510 degrees	
Light purple	520 degrees	Twist drills, flat drills and wood working tools.
Dark purple	530 degrees	
Light blue	550 degrees	Screw drivers, punches, cold chisels, etc.
Blue	560 degrees	
Dark blue	600 degrees	
Black........above	650 degrees	

SOLDERING.

It is absolutely essential that the student of automotive trade work acquire a knowledge of soldering and be able to do a neat piece of work. Soldering as required about the motor car is frequently difficult and tedious. It is difficult because of the amount of oil, dirt, and grease which collects on the parts requiring repairs of the nature possible with soldering. Gasoline tubes and tanks, carburetor and vacuum floats and other parts, as well as parts of the electrical equipment system are those requiring a knowledge of soldering in order to make repairs in a workmanlike manner.

The first essential in all solder work is absolute cleanliness. The second is proper means of heating the iron and the third is a good flux. Solder may be purchased in the bar form or in the wire form. The last mentioned is most suitable for the varied work about the garage.

Fluxes.—There are a number of fluxes on the market. If the garage does not do this kind of work regularly the most satisfactory flux is what is known to the trade as soldering salts. This flux may be purchased from the supply houses in pound bottles. To use the salts they are mixed with water. The strength of the solution may be varied at will so that a piece of work requiring a strong flux may be handled as readily as a piece such as tin which requires only a weak flux.

Where a considerable bit of work is done the acid preparation is recommended. To prepare this, secure muriatic acid from a wholesale druggist or the supply house. Place a quantity of the acid in a glass or earthenware vessel. Add to the acid as much scrap zinc as it will eat away. This is called cutting the acid.

For electrical work and certain other work a paste preparation called "soldering paste" is recommended. This may be secured from supply houses. Powdered resin forms a splendid flux for electrical and similar work. Acid must not be used in certain places about electrical equipment.

JOB 236. TINNING A SOLDERING IRON.

The proper care of the soldering iron is a prerequisite to good solder work. The body of the iron is made of copper. This may be filed or it may be drawn out on the tip to the proper shape. In drawing out by hammering, the copper is first heated to a dull red and then cooled in water thus annealing it. The point as a rule should be kept rather long. This permits of doing better work on the small intricate parts needing repairing, in the average run of work in the garage.

1. With the point of the iron of the proper shape, it is filed bright and clean.

2. Heat in the furnace, on the torch, or by any other means. A clean blue flame is preferred for this work although the iron may be heated in the coal fire.

3. Remove the iron from the fire and dip the point into a vessel containing a small quantity of soldering salts or other flux.

4. Work the iron onto a piece of clean tin on which a few drops of solder have been melted. Continue dipping it into the flux and working on the tin until an even coat of solder is provided well back on the point of the iron.

5. While working with the iron, each time it is withdrawn from the fire, it should be dipped momentarily into the soldering flux in the vessel especially kept for this purpose. This has the effect of keeping the point of the iron permanently bright. At the end of a day's work it will be found that a surprising amount of dirt, cross or sediment has collected in the bottom of this vessel.

6. Acid or other flux may be used in this process of tinning.

7. The usual method of tinning the soldering iron or copper in the tin shop is somewhat different from the above. Salamoniac is used to clean the iron in this case but it is a bit more difficult to manipulate. Where it is used in a block the solder is melted into the hole caused by working the iron in one spot on the surface of the block. When used in the powdered form the point of the iron is dipped into the box containing the salamoniac and then the operation carried out as outlined for the flux.

8. The coat of tin or solder will be burned off if the iron is heated to too great a degree. The first sign of this is a blue color to the tin which will shortly turn brown and flake off if the heat is continued.

9. It is useless to attempt even the smallest piece of work without properly tinning the iron.

JOB 237. SOLDERING A LEAKY CARBURETOR FLOAT.

In many cases the hollow metallic float is in use in carburetors. In the course of months of service the gasoline will in some cases find its way into the inside of the float. To correct this trouble proceed as follows.

1. The presence of gasoline is detected by failure of the float to operate properly. Remove the float. Shaking it past the ear of the workman will give forth the sound indicating a confined liquid.

2. If not certain where the gasoline entered the float place a pan of water on the stove and bring it to the boiling point. Place the float in this pan. The gasoline vaporizing at a point lower than that of the boiling point of the water will be driven off from the float in the form of bubbles. The points at which the bubbles appear indicate the points at which the gasoline entered.

3. Punch two small holes in the float on the opposite sides.

4. Blow into one of these and all of the gasoline will be forced out of the lower one.

5. After all the gasoline is out, the float may be repaired by soldering the two holes punched in the float and those located by the above method.

6. Too much solder piled on the float will take away its buoyancy. A very thin coat is sufficient to hold.

JOB 238. REMOVE CARBON BY BURNING.

In certain types of engines which are not fitted with removable heads, the job of removing carbon is rather difficult. Scrapers may be used but this is a tiresome tedious task. Since carbon and oxygen have a great affinity for each

Fig. 675. Oxweld Carbon Removing Outfit.

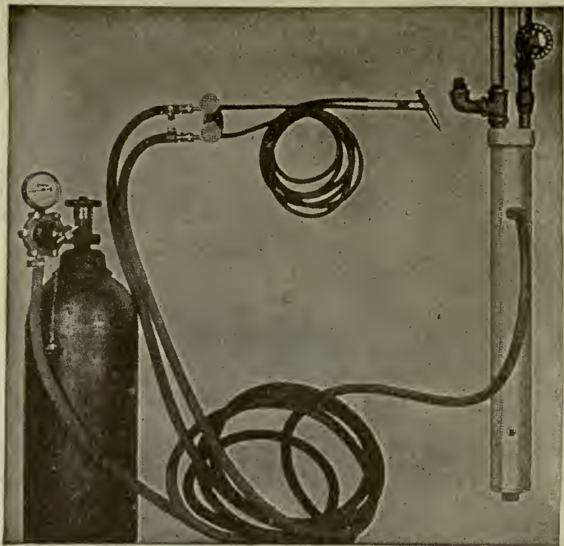


Fig. 676. Oxygen and Natural Gas Lead Burning Equipment (Oxweld).

other, this fact is taken advantage of and oxygen from the welding tank is used to complete combustion and burn out the carbon from the inside of the cylinder walls. Fig. 675 shows the type of blowpipe used for this work.

1. Remove a spark plug or a port plug from the engine cylinder.
2. Put the piston in the cylinder being worked on, on T. D. C. compression stroke.

Fig. 677. Oxygen and Acetylene Lead Burning Equipment (Oxweld).

3. Light a match and permit it to burn until the match stick is well afire.
4. Having the oxygen regulator valve and blowpipe set for a light pressure and ready to operate, the lighted match is dropped into the cylinder.
5. Immediately the long flexible tube of the blowpipe is inserted and the combustion of the oxygen takes place. This is evidenced by brilliant white

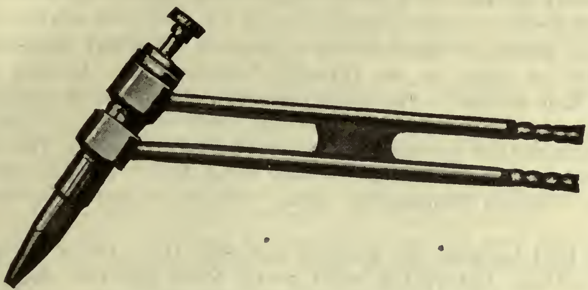


Fig. 678. Oxweld Lead Burning Torch.

sparks coming from the cylinder and a roaring sound. Sometimes in cases of cylinders very badly carbonized the combustion is accompanied with loud explosion-like reports. Keep the tip of the blowpipe moving about in the cylinder until all recesses have been reached. When no more carbon is present the combustion can no longer be maintained. Test the cylinder after the flame goes out by dropping in another burning match and attempting to start combustion.

6. Treat each cylinder in turn.

LEAD BURNING.

Storage battery work requires a knowledge of lead burning or lead welding. Whenever two pieces of the same metal are joined together by fusion they are said to be welded together. Fusion means that they are heated to such a

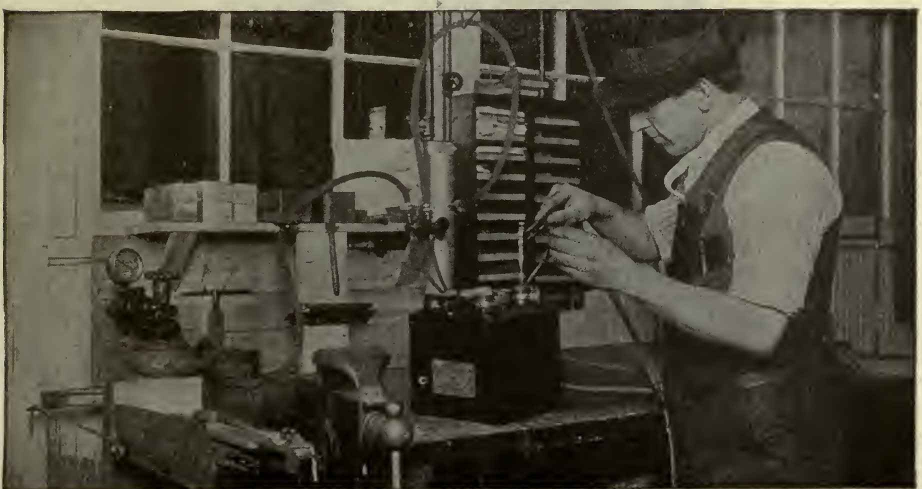


Fig. 679. Oxweld lead-burning equipment using oxygen and city gas—welding battery terminal straps.

point that they melt and are thus joined in one piece. In welding lead the filler rod used is lead. The groups of plates are burned together. This work is done in the factory. Where a single plate is joined to an old group it must be burned in, as lead welding is called in the repair shop. The lead connector straps are burned to the group posts. Lead burning has been found to be the most satisfactory means of joining the battery parts together. Any other method is very likely to cause trouble due to the corrosive effects of acid.

Figs. 676 to 678 show lead burning equipment. Fig. 677 shows the oxygen-acetylene outfit as made by the Oxweld Acetylene Co. In this instance an acetylene gas tank similar to that used for automobile lighting is used to supply the acetylene gas. The oxygen is supplied from the taller of the two tanks. Oxygen is a commercial product and may be secured in any of the larger cities. The same blowpipe shown in Fig. 676 may be used with oxygen and natural or artificial gas. Certain companies make torches suitable for oxygen and hydrogen.

In actual lead burning the greatest difficulty is to bring the parts to the fusing point without having the walls break down and run away. Lead will retain its shape until the melting point is reached over a considerable area. When it starts to collapse the action is very sudden. In burning lead straps onto the storage battery care must be used to prevent the entire end of the strap reaching the melting point. Too large a flame will result in this trouble.

The lead burning operation may also be used about the battery shop to burn leaden vessels together. These vessels are used as acid containers.

The small flame of the lead burning outfit is of service in welding thin sheet metal, or in brazing small parts.

Fig. 680. Oxweld burning on battery connecting straps.

JOB 239. BURNING CONNECTOR STRAPS ON BATTERIES.

In dismantling a battery the lead connector straps are removed by drilling. Assemble these in place and proceed to burn them onto the posts as indicated in Fig. 680 and the steps outlined below.

1. Have the terminal post extending into the strap end about one-third of the way.
2. Place the flame into the hole until it is almost against the top of the post.
3. The top of the post and the bottom of the link or strap should be melted together as rapidly as possible.
4. Fill the hole with the welding rod seeing that the portions filled in actually fuse with the walls of the hole.
5. It is sometimes advisable to only partially burn in the one end before giving it a chance to cool, thus preventing it breaking down.
6. After the link is welded, the top is leveled off with the blowpipe. Use a wire brush to remove any oxide or scum tending to collect on the top of the finished weld.

OXY-ACETYLENE WELDING.

Oxy-acetylene welding consists of melting the edges of two pieces of metal so that they run together and become solid when cold. In order to do this a very hot flame is used. This flame is produced by burning together two gases, acetylene and oxygen. The equipment required consists of a cylinder or tank of oxygen, a tank of acetylene, two regulators or reducing valves—one for the acetylene tank and the other for the oxygen tank—a welding blowpipe, and two pieces of hose to connect the welding blowpipe to the regulators.

Oxygen.—Oxygen is a gas that is used to help burn the acetylene. If it were not for this gas, the high temperature of the flame could not be secured. Oxygen does not burn itself. It merely helps the other gas to burn. It has no odor and is invisible. It is usually supplied in steel cylinders or tanks. The standard cylinders hold 200 cubic feet of oxygen. The oxygen is pumped into these cylinders at 1800 lbs. pressure. The amount of oxygen in a cylinder can be determined by looking at the high pressure gauge of the regulator. We know that when the cylinder is filled—when the high pressure gauge shows 1800 lbs.—there are 200 cubic feet of oxygen in the cylinder. If the pressure is 900 lbs., which is one-half of the pressure when filled, there will be just half as much oxygen in the cylinder, or 100 cubic feet. Likewise, if pressure on the big gauge should show 450 lbs. in the cylinder, there would be one-quarter as much, or 50 cubic feet. In general, for every 9 lbs. pressure below the filling pressure of 1800 lbs., there will be 1 cu. ft. less of oxygen in the cylinder. A mixture of oxygen and gas, being explosive, should be avoided in the presence of a flame. Oxygen also will combine with grease, oil, or other inflammable materials with explosive violence. The oxygen regulator and the valve of the oxygen cylinder should therefore not be greased or oiled at any time. Care must be taken that the gauges on the regulator have no oil or grease on them. An oxygen cylinder. when filled, should be handled carefully, because there is such a high pressure within it. Do not knock it over or drop it. When the cylinder is not in service, the valve should be protected by means of a cap, which comes with it. Before attaching a regulator to the cylinder valve, always first 'crack" the valve (open the valve slightly) both to clean out the valve and to see that it is operating properly.

Acetylene.—Acetylene is the gas that burns in the oxy-acetylene flame. When it is burned alone, without any previous mixture of oxygen, it produces a yellowish, smoky flame. When mixed with oxygen, it produces a bluish white flame. It is an invisible gas, but has a distinct odor.

Acetylene is made by dropping a grayish, stone-like substance, called calcium carbide, into water. The acetylene bubbles up through the water, leaving a white sludge at the bottom of the vessel. This sludge is slaked lime.

The machine in which acetylene is made is called an acetylene generator.

Oxweld Welding Unit

Fig. 681.

Acetylene Tanks.—It is not possible to compress acetylene at a high pressure into an empty tank, as is done with oxygen. This is because acetylene at a high pressure will explode. For this reason a different style of tank is used. Inside the tank is placed a material that is porous. This material is soaked in a liquid called acetone. Acetylene will be dissolved in this liquid just like sugar is dissolved in water. When acetylene is pumped into a tank of this kind, it is safe. It is never pumped up to a pressure above 250 lbs. The usual tank of acetylene contains 300 cubic feet of gas.

No blowpipe that will empty it in less than seven hours should be used on

any acetylene tank. If the tank is emptied in a shorter time than this, the liquid will be drawn out of the tank. Do not drop or jar an acetylene cylinder. Handle it carefully. Always keep an acetylene cylinder in as cool a place as possible. Do not stand it near a fire. If possible, it should be kept out of the hot sun.

Before connecting an acetylene regulator to a tank, be sure that the cylinder valve is operating properly and that there is no leakage around the nut of the stem. Because acetylene is inflammable, all leaks in the cylinder

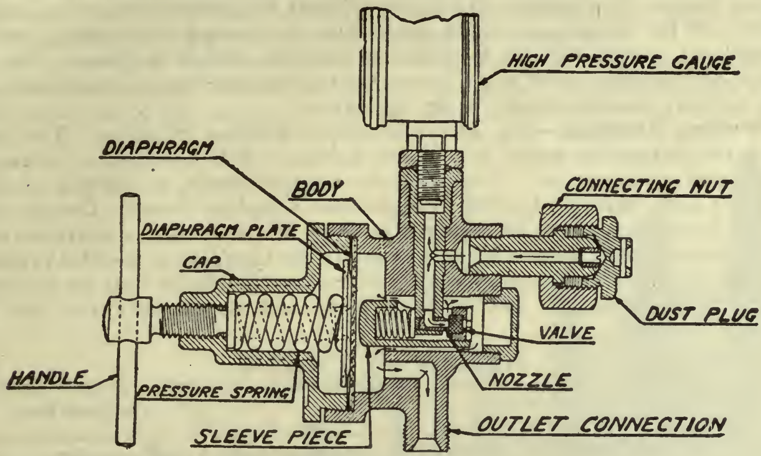


Fig. 682. Regulator.

valve, hose, and connections should be avoided. If there is a cap supplied for the tank valve, always see that this is in place before moving the cylinder. Do not transfer actylene from the cylinder to an empty tank. Avoid large volumes of acetylene under pressure. Acetylene will act on pure copper so that it will produce an explosive compound. Because of this, never use copper in acetylene equipment. Brass or bronze, however, can be safely used. Never use acetylene at any time at a pressure above 15 lbs. Beyond this it is dangerous. Do not attempt to locate a leak in the acetylene connections with an open flame. To locate a leak use soap and water with a brush. When the leak is located, bubbles will appear.

Because acetylene is not compressed in an empty tank like oxygen, but is dissolved in a liquid, it is not possible to determine the amount of acetylene being used by the gauge readings. This may be determined, however, by

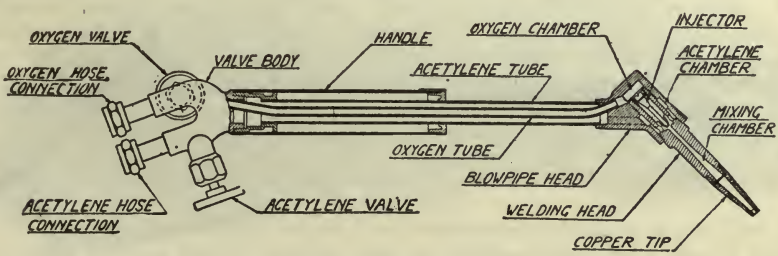


Fig. 683. Blowpipe.

weighing the tank before and after the job. There are 14½ cu. ft. of acetylene to a pound.

Regulator or Reducing Valve.—A regulator or reducing valve is used in an oxy-acetylene unit to reduce the pressure of the gas and to keep this pressure constant or even. Fig. 682 shows a section of one type of regulator. The regulator is a delicate device, very sensitive, and must be handled very carefully. Never drop or jar it. Do not use oil, grease, or such material for lubrication in connection with the oxygen regulator. Keep as much dust and dirt out of it as possible, by inserting the dust plug when the regulator is not in service. Do not change the regulator from one cylinder to another without taking the pressure off the diaphragm, which can be done by turning the handle to the left. A regulator should not be repaired by any but skilled workmen. Do not replace diaphragms, valve seats, springs, or other wearing parts, except with those actually manufactured for the regulator.

Welding Blowpipe.—Fig. 683 represents a welding blowpipe. The blowpipe is the instrument which is used for welding It is designed to be easy of control and manipulation. It consists of a tubular handle, in one end of which is a valve body carrying both the oxygen and acetylene valves. On the other end is a head into which are inserted welding heads or tips of different sizes. The mixture of gases occurs in these tips. If the blowpipe is handled properly, it should not require a great amount of attention. It should only be necessary to clean the removable and working parts and occasionally the tips and

WELDING TABLE

Thickness of Metal In.	Size of Welding Head or Tip		Oxygen Pressure Lb. Per Sq. In.		Per Hour				Per Linear Foot		
					Speed		Gas Consumption		Gas Consumption		Iron Filling Wire Lb.
					Best Condition Lin. Ft.	Shop Practice Lin. Ft	Oxygen Cu Ft	Acetylene Cu. Ft.	Oxygen Cu. Ft	Acetylene Cu. Ft	
	W-3	W-1	W-3	W-1							
1/64=No. 28	1		4		30	26	3.5	3.3	0.14	0.13	
1/32=No. 22	1	2	6	9	26	22	4.5	4.2	0.20	0.19	0.005
3/64=No. 18	2		8		23	19	5.5	5.2	0 29	0.27	0.007
1/16=No. 16	3	3	10	10	21	17	6.6	6.2	0.39	0.37	0.01
3/32=No. 13	4	4	11	11	17	14	8.7	8.3	0.62	0.59	0.02
1/8=No. 11	5	5	12	12	14	11½	10.8	10.2	0.94	0.89	0.04
3/16		6		14	11	9	15.0	14.2	1.67	1 58	0.08
1/4		7		16	9	7	19.2	18.3	2.74	2.62	0.15
3/8		8		19	6¼	4½	27.6	26.3	6.13	5.85	0.3
1/2		10		21	4½	3	36.0	34.3	12.0	11.4	0.6
3/4		12		25	2¾	1½	52.8	50.4	35.2	33.6	1.4
1 and Over		15		30	2	1	69 7	66.3	69.7	66.3	2 4

Fig. 684. Blowpipe.

passages of the welding heads. The tips should never be cleaned out with anything but a soft copper or brass wire. If something harder is used, the hole will become larger and the head will not work so well. Occasionally dirt can be blown out of the head by means of high oxygen pressure. If the flame is not properly adjusted, or the tip becomes clogged, the blowpipe may backfire. When this occurs, close the acetylene valve for a few seconds. Then open this valve fully and re-light the blowpipe. If the backfire continues, close both the acetylene and oxygen valves, then relight the blowpipe. If the blowpipe becomes heated, it may be cooled by plunging it into a bucket of water. When this is done, be sure that the acetylene has been shut off and a small quantity of oxygen is passing through the blowpipe.

The blowpipe may be cleaned by removing both the acetylene and the oxygen hose and then connecting the tip of the head to the oxygen hose. Then turn on about 20 lbs. oxygen pressure. The acetylene valve must be opened

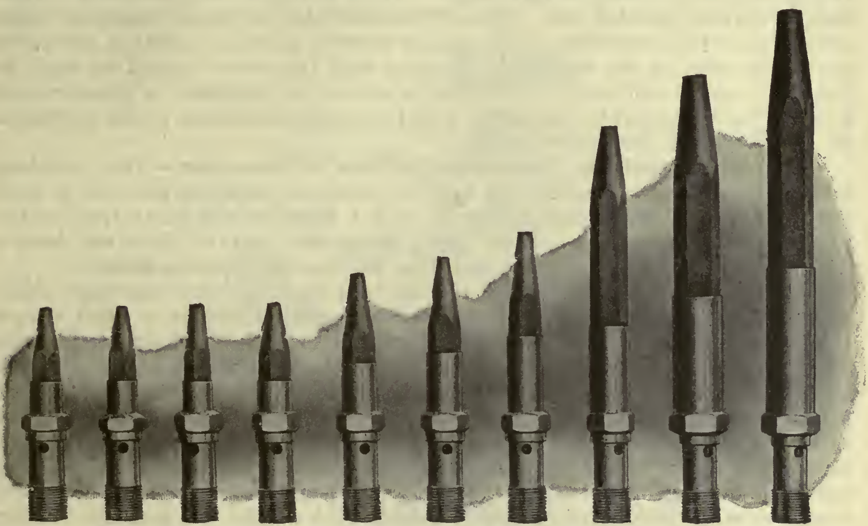


Fig. 685. Oxweld welding heads.

and the oxygen valve closed. This will drive any dirt or carbon through the larger acetylene passages. After this is done, the acetylene valve should be closed and the oxygen valve opened. This will clean out the oxygen passages.

Hose.—Two colors of hose are used, black for acetylene and red for oxygen. This is to prevent interchanging when connecting the apparatus. All hose connections must be tight. A good hose clamp should be used. Both acetylene and oxygen hose should be blown out occasionally so that dirt and dust will not be carried into the blowpipe.

Welding Heads.—There are ten sizes of welding heads supplied with a blowpipe. Each of these heads gives a certain size flame. Each of these flames is to be used on different thicknesses of metal, as is shown by the table on page 586. The acetylene pressure for all the heads is the same—namely, 1 lb. The oxygen pressure varies, ranging from 9 to 30 lbs., according to the size of the head.

Oxy-Acetylene Flame.—When the oxy-acetylene flame has just the right proportion of each gas, it is called neutral. This is shown by a clearly defined central cone, bright bluish green in color, surrounded by a bushy, weak flame,

purplish yellow in color. When too much oxygen is used, this central cone or jet becomes bluer in color, and loses the greenish tinge; it is not so clearly defined. When too much acetylene is used, the jet becomes bluish white and is streaky. The neutral flame should always be used. The student should test his flame from time to time as he is welding. This is done by turning on a slight excess of acetylene, by means of the acetylene valve, and then trimming it down so that a neutral flame is produced.

CONNECTING AND STARTING THE WELDING UNIT.

Attaching Regulator That Controls Flow of Oxygen.—The oxygen tank is the taller, with the flat bottom and the bullet shaped head, covered with a metal cap. This cap must be unscrewed. Under the cap is a valve. Slightly open this valve to allow the oxygen to escape in order to remove the particles of dust or dirt which may have collected. The tank is usually painted gray and green, red, yellow, or dark green. With each outfit is furnished a two-gauge regulator painted red. Remove the dust plug from the regulator union nut. Attach this regulator to the oxygen cylinder valve by means of the union nut in the back of the regulator. Be sure that this nut is pulled up tight so that no oxygen will leak. With each regulator is furnished a piece of red hose. This hose must be connected with the outlet connection of the regulator. Be sure that this connection is tight.

Attaching Regulator That Controls Flow of Acetylene.—The acetylene tank is the shorter and stouter of the two tanks, and has a depression at both ends. In one of these depressions is fixed a valve of the same type as the valve in the oxygen tank. These tanks are always painted black and have a name plate on them giving the quantity of gas that the tank contains.

Open the valve very slightly to blow out any dirt that may have accumulated. With each outfit is furnished an adapter, which is a small curved brass connection that connects the tank and regulator. This adapter must be fitted to the valve. Most acetylene cylinder valves have left-handed threads, and for this reason the adapter is left-handed. When the adapter has been attached to the cylinder by means of the male connecting nut and stud, the regulator is fastened to the other end of the adapter by means of a connecting nut similar to the nut of the oxygen regulator, but threaded left-handed. The acetylene regulator is usually the same in design as the oxygen regulator, except that it is painted black and the gauges on it are for low pressure. When the acetylene regulator is tightly connected, the acetylene hose is attached to the outlet of the regulator. This hose is usually black in color.

Blowing Out Hose to Clean.—Before going any farther, it is necessary that we blow the hose out to remove dirt and dust. This is done as follows:

Slowly turn on the oxygen valve. This valve should be turned to the left by means of the hand wheel on it until the valve is open as far as it will go. The pressure of the oxygen in the cylinder will show on the big gauge. If the cylinder is full this big gauge will read 100 per cent at 1800 lbs. Then turn the handscrew of the regulator to the right until oxygen passes through the hose. Keep turning the handle until a pressure of about 5 lbs. shows on the small or low pressure gauge. Let the oxygen pass through this hose for a few seconds, and then turn the handle of the regulator to the left until the flow of oxygen stops.

Now slowly open the valve on the head of the acetylene tank by means of the wrench supplied. This valve should never be opened more than two full turns. The pressure in the acetylene tank will then be shown on the big gauge. This pressure will be about 250 lbs. when the tank is full. The handscrew of the regulator should then be turned to the right until a small amount of acetylene passes through the hose. Care must be taken that no fires or flames

are near at the time, otherwise the acetylene will become lighted. The gas is allowed to flow through the hose until all dirt is removed. This should not take more than five seconds. When the hose is clean, the handle of the regulator should be turned to the left until the flow of gas is stopped.

Connecting Blowpipe.—We are now ready to connect the blowpipe to the hose. First, connect the oxygen hose from the oxygen regulator to the hose connection on the blowpipe marked oxygen. Likewise connect the acetylene hose to the blowpipe valve marked acetylene. Then select the proper welding head or tip that is to be used according to the chart or table furnished you, and screw it carefully into the blowpipe. Turn on the oxygen by means of the handscrew of the oxygen regulator until the pressure on the small gauge is as given on the chart. Be sure that when this is done the oxygen valve on the blowpipe is open. Then close this valve, and open the acetylene valve on the blowpipe. Now turn the handscrew on the acetylene regulator to the right until acetylene is passing through the blowpipe, and close the acetylene valve on the blowpipe.

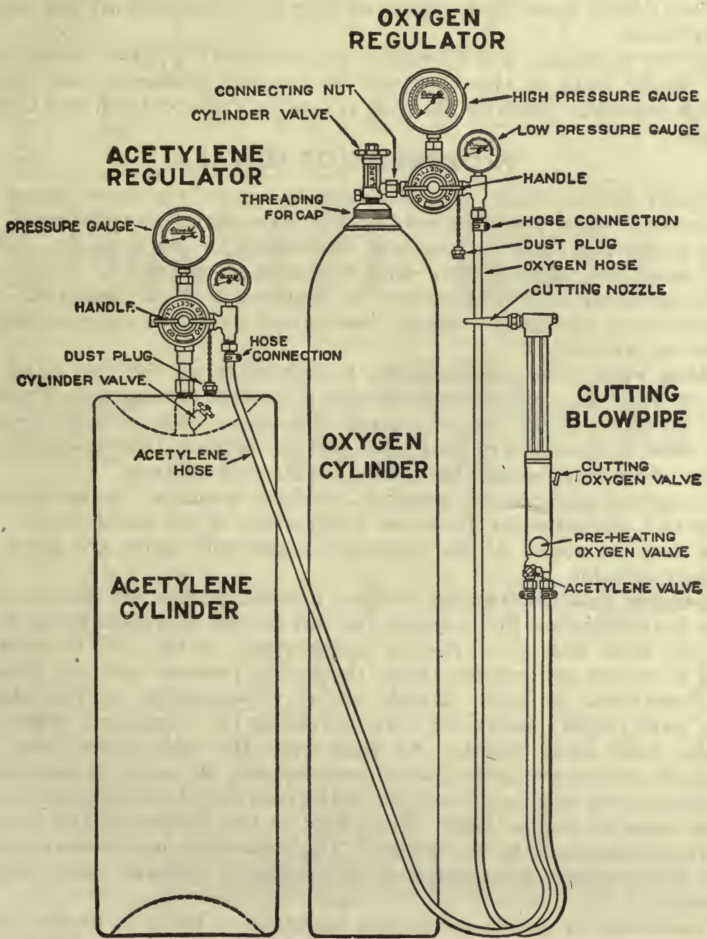


Fig. 686. Oxy-Acetylene welding unit.

Lighting Blowpipe.—The apparatus is now ready for use, and the gases are further regulated when necessary by adjusting the valves on the blowpipe itself. Open the acetylene valve entirely. Open the oxygen valve slightly. Then light the gases. After lighting the gases, open the oxygen valve wide; adjust the flame by turning the acetylene valve to the right until a neutral flame is produced.

To Shut Off Blowpipe.—When the job is finished and you want to shut off the blowpipe for a short time, release or turn the handscrew on both oxygen and acetylene regulators to the left until the flame on the blowpipe goes out, after which close the blowpipe valves. When work is completed for the day and the apparatus is to be put away, first close the acetylene valve, and the oxygen valve of the blowpipe and turn off the valves on both cylinders. Then open the valves on the blowpipes until all the gas in the regulators and hose passes out of the blowpipe into the air, and turn the handscrew of both regulators to the left until loose. Then disconnect the oxygen and acetylene regulators from the cylinders. Each regulator has a dust plug which is to be put on its cylinder connection during all time the regulators are not connected to the cylinders.

Place the regulators and blowpipes with wrenches, goggles, heads, and tips in their proper place so that they will be safe and protected from dust, dirt, and rough handling. Roll up the hose and put it in the case or tool box where it belongs.

PROPERTIES OF METALS.

In order that a welder may intelligently handle the work placed before him he must be able to immediately establish the identity of the metal, recognize its properties, have a complete knowledge of its behavior under the welding flame, and know exactly what treatment to give it.

This necessary knowledge cannot be acquired within a short time. It will result only from experience, careful observation, and close examination of the work during welding.

Melting Point.—The first property to be considered, common to all metals, is the melting point. Autogenous welding is the joining together of two metals by uniform fusion at the line of contact. In other words, in order to secure a perfect weld it is necessary that each part be melted, and the molten metal allowed to flow together and harden in this state of mixture.

The melting point of any metal is a definite quantity. If the temperature is raised to a certain point, fusion or liquefaction of the metal occurs.

The melting points of the principal metals and alloys are given in the accompanying table.

Expansion and Contraction.—When metallic bodies are subjected to an increase in temperature they expand, the rate of this expansion being definitely known for each degree of rise in temperature. When the temperature is lowered a reverse action takes place, the bodies contract and the volume and linear dimensions decrease. Metals are very susceptible to this change in volume, each metal having its own coefficient of expansion, which varies materially from other metals. As seen from the table given here, of the metals most commonly welded aluminum expands the most, bronze and brass next, then copper, steel, and iron. It will be seen that aluminum expands almost twice as much as iron or steel. The effect of this expansion and contraction is of great importance to the welder. The expansion and contraction of the welded piece cannot be controlled mechanically, because these forces are irresistible.

In malleable or ductile metals the expansion is liable to produce warping or deformation of the piece, while in materials that are not of this nature—

PROPERTIES OF METALS

Metals	Weight Lb. Per Cu. In.	Tensile Strength Lb. Per Sq. In.	Coefficient of Linear Expansion Per Degree F	Specific Heat	Melting Point Degree F.	Relative Heat Conductivity Copper W1.00	Latent Heat of Fusion B. T. U's per Lb.
Cast	.0924	12000–14000	.0000123				
ALUMINUM				.2185	1215	.504	180
Drawn	.0967	25000–55000	.0000136				
Cast		18000–20000					
BRASS	Cu–60 Zn–40 .3036		.00000957	.0939	1740	.204	
Drawn		40000–78000					
BRONZE	Cu–90 Sn–10 .3132	36000	.00000986		1650–1750	.735	
Cast		24000					
COPPER	.3186		.0000093	.09515	1982	1	77.9
Drawn		30000–60000					
White Cast		13000–22000			1922–2075		43.4
IRON	.2840			.1138		.152	124.2
Grey Cast		18000–29000	.00000556		2228–2786		59.4
WROUGHT Iron	.2779	50000–90000	.00000648	.1138	2732–2912	.156	
LEAD	.4108	1720–2050	.0000162	.0314	621	.076–083	9.66
NICKEL	.3179	54000	.0000071	.1086	2645	.14	122.4
Cast	.2479						
ZINC		5000–7000	.0000161	.0955	786	.303	40.6
Rolled	.2598						
Mild	.2834	55000	.0000063	.1165	2687	.139	
STEEL							36
Hard		78000		.1175	2370		

brittle materials such as cast iron—the result of the expansion or contraction, unless properly cared for, is breakage.

Conductivity.—The conductivity of a metal is its property of transmitting heat throughout its mass. This property is not the same for all metals, and varies within wide limits. It is commonly called thermal conductivity.

It can be seen that if one metal conducts or transmits the heat from the welding blowpipe throughout its mass more rapidly than another, it is necessary that allowance be made as to the method of handling the job, the size of the blowpipe, and the nature of the preheating equipment used.

In welding metals of high thermal conductivity it is necessary to use oversize blowpipes—as in the case of copper. While the melting point of copper is low, yet the conductivity is high, and consequently a blowpipe head of larger size than would be used on a similar thickness of steel must be employed.

The conductivity of a metal will have a great bearing on the correct way of considering the problem of expansion and contraction. If one metal absorbs or leads the heat away from the welding blowpipe more rapidly than another, the heated area will become very much larger; and consequently the expansion and contraction strains are affected proportionately.

Oxidation.—Oxidation is the reaction produced by the combination of oxygen with a metal. The weld may become oxidized by contact with the oxygen in the air and by the presence of excess oxygen in the welding flame. An oxide has none of the metallic properties of the metal from which it is formed. When present in a weld it is an impurity, and it is therefore very necessary that it be avoided as far as possible.

Some oxides are lighter than the metal itself, while others are heavier. Consequently, when a metal is reduced to a molten condition the oxide will either float on the surface of the liquid metal or sink to the bottom of the weld. It can be seen that the sinking is the least desirable, as the presence of the oxide in the weld itself is extremely bad.

The melting point of oxides is in some cases higher, and in others lower, than that of the original metals. This point must be considered in attempting to eliminate oxide from the weld.

Certain metals when molten also have the property of dissolving a portion of the oxide, the extent of this solution being dependent upon the metal itself. When this is the case the oxide is retained in solution until the metal hardens, in some cases separating and producing a weakened weld, in others being retained permanently in solution as an alloy.

Oxide may be dealt with in two ways. First, by taking such means as possible to prevent its formation, by the use of a neutral or reducing flame in the blowpipe as required, or by the uses of various cleaning fluxes, etc. Second, by eliminating the oxide after its formation with suitable fluxes, which either dissolve or float it off, or by mechanically removing it by the manipulation of the welding rod or a paddle made for this purpose.

The subject of oxidation is one of vital importance to the welder, one that he should study thoroughly in order to become familiar with all its forms. It is due to oxidation that the great majority of defective welds are faulty.

PREHEATING.

In autogenous welding it is essential that the welding be preceded by some preliminary heating operation, as there are many advantages to be gained by this treatment.

Preheating is employed for two reasons: first, to prevent the effect of expansion and contraction; second, to decrease the cost of welding by supplying from a cheaper source a considerable volume of the heat required.

When a weld is being done on a large casting, it is entirely too expensive to supply the total amount of required heat from the blowpipe alone. To offset this, preheating by some cheaper method is used; and the result is usually a saving of from 25 to 60 per cent of the cost of welding. Not only is a great saving in gases effected, but it is possible to accomplish the welding with greater speed, due to the casting being at a higher temperature when welding is started.

There are various means of carrying out this preliminary heating. The simplest, and one of the most used on light objects, is that of utilizing the secondary or envelope flame of the welding blowpipe. In welding thin castings and thin sheet metal work, the secondary flame of the blowpipe needs to be played upon the parts at the line of the weld for only a few seconds in order that the pieces attain a red heat.

If the article to be welded is of fairly large size the use of a gas or oil burning preheating torch is economical. These preheating torches, however, limit the area of the surface covered. They are consequently used more successfully on that work which requires localized preheating. The flames produced are of sufficient temperature, but not the necessary volume to evenly heat the entire casting of any great size. Then, too, the heating zones of these burners vary because they are operated with an air blast which, unless unusually well controlled, fluctuates in pressure.

A common method of preheating is by means of a charcoal or coke fire built around the article to be welded. The usual procedure is to build a small temporary fire brick furnace around the piece and then fill in with coke or

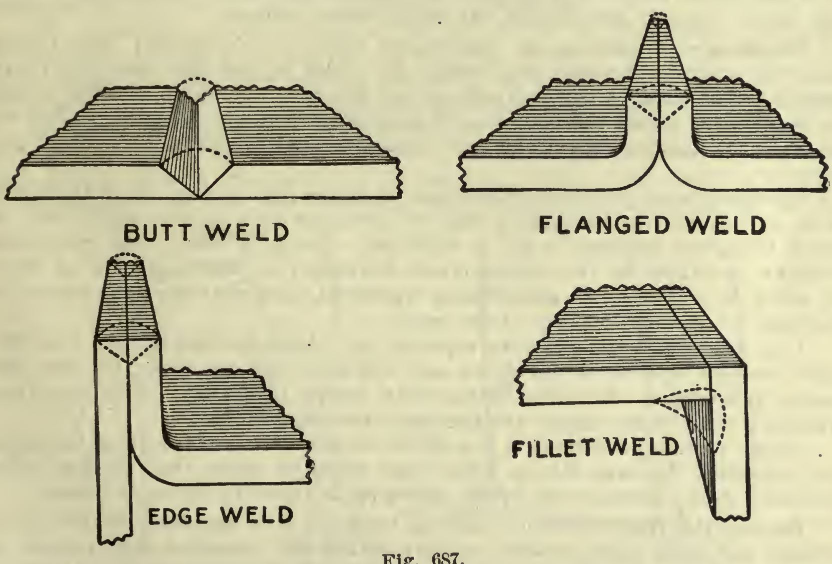


Fig. 687.

charcoal loosely set up. Occasionally coke and charcoal are mixed. This is ignited by means of kerosene. As the combustion of the charcoal or coke is rather slow, the preheating is carried out gradually and evenly. An air blast should not be used.

In welding large castings of a complicated nature it is necessary that they be preheated evenly throughout, and that the welding be carried on while the casting is at a dull red temperature. It is impossible to do this while gas or oil burners are playing on the casting, as the blast of these blowpipes is such

that it would seriously interfere with the working of the oxy-acetylene flame. Therefore, the most satisfactory way to accomplish this is to partly bury the casting in charcoal or coke and carry on the work while it is buried in the hot coals. The cost of this method is less than that of any other, and because of its ease of application it is used more generally by welders.

Where it is necessary to preheat many castings of a similar nature, such as gas engine cylinders, furnace sections, etc., it is best that a permanent preheating oven or furnace be installed. These furnaces may be designed particularly for the work they are to receive, and the fuel used can be coal, coke, charcoal, gas, or oil. In some cases the furnaces are muffled—that is, the flame is not allowed to play directly on the casting; in others the casting is laid directly in the flame. With suitable draft controlling arrangements it is possible to establish a fairly constant temperature in these furnaces, the advantages of which can be readily seen.

PREPARATION OF WELDS.

The success of oxy-acetylene welding depends, to a very great extent, upon the proper preparation of the parts to be welded. While the preparation of a weld depends very much upon the particular location and condition of the parts to be welded, there are nevertheless certain general rules that must be followed. The preparation should be given as much consideration by the welder as are the proper selection of welding rods, fluxes, and size of blowpipe head. The weld that is not prepared properly will usually offset any skill that the welder may have. Careless preparation has caused many failures.

Bevelling.—In making an autogenous weld, it is necessary that fusion penetrate entirely through the metal. In order to aid this the pieces are usually champfered or beveled with an air hammer, a grinder, or cold chisel. By bevelling is meant the grooving or champfering of the metal at the line of the weld, the depth of this groove or V being equivalent to the thickness of the metal.

Bevelling is not required on castings or plates lighter than $\frac{1}{8}''$ in thickness From $\frac{1}{8}''$ to $\frac{3}{16}''$ in thickness a narrow champfer only is necessary; one in which the angle opening is 90° is sufficient. From $\frac{3}{16}''$ up to the maximum thickness weldable by the oxy-acetylene blowpipe, an angle opening of from 60° to 90° is sufficient, the angle being dependent somewhat upon the nature of the material and the location of the weld.

It is not sufficient to merely separate the edges, because in this case the upper corners will be melted down and will flow into the space between the pieces, adhering to the sides rather than fusing intimately. This does not produce a weld in any sense, as experience speedily shows.

Under certain conditions it is possible to use an oxygen cutting blowpipe for bevelling. In case this is done, care must be taken that all the oxide produced on the surfaces cut by the blowpipe be removed before welding.

Setting Up Work.—Before starting to weld, it is necessary to adjust or arrange the parts to be welded, so that during the operation they remain in relatively the same position. It is a common fault of inexperienced welders to overlook this important item, and consequently the strength of the weld, as well as the progress of the work, will be seriously affected. In lining up a piece it is essential that the deviation from the original lines, caused by expansion and contraction, must be thoroughly understood and cared for.

In repairing castings of nonmalleable nature, the adjustment before welding should be very carefully done. This adjusting is usually carried out by means of straight edges, jig clamps, keys, wedges, and other devices.

CHARACTER OF FLAME.

The combustion of acetylene in oxygen produces a two-phase flame. The luminus cone or jet indicates the following re-action:

$$C_2H_2 + O_2 = 2CO + H_2$$

The oxygen in this reaction is supplied from the cylinder. It is at this point that the endothermic energy of acetylene is released.

The bushy non-luminous envelope shows this combination:

$$2H_2 + O_2 = 2H_2O$$
$$2CO + O_2 = 2CO_2$$

The oxygen in this phase is supplied by the atmosphere.

The character of the oxy-acetylene flame depends upon the proportion of oxygen and acetylene contained in the mixed gas as it issues from the tip of the blowpipe. This proportion is controlled to some extent by regulators or other devices installed with the equipment. The final adjustment, however, should be with the needle valves of the blowpipe. The proportion of oxygen is approximately regulated by adjusting the oxygen regulator to the proper pressure as shown in the table on page 586. The acetylene is also regulated when using a medium pressure generator, or dissolved acetylene from tanks, by means of various regulators and regulating devices. In the use of low pressure and acetylene generators it is not necessary to use devices such as this, since the correct amount of acetylene is drawn into the blowpipe by means of an injector in the welding head or blowpipe.

The proportion of the gases may produce three divisions in the character of the flame—called reducing or carbonizing, neutral, and oxidizing. The welder should at all times observe carefully the type of flame produced, and any divergence from the type desired should be instantly detected and corrected.

Reducing or Carbonizing Flame.—When the blowpipe is first lighted the acetylene is greatly in excess. The flame produced is of abnormal volume, a dirty yellow color, and of uniform consistency. This is the reducing type in an exaggerated degree. By increasing the oxygen pressure the size of the

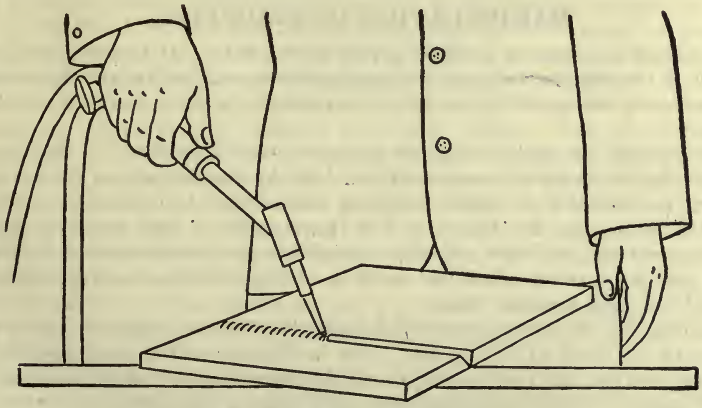


Fig. 688. Welding position.

flame is lessened, and gradually a white zone of greater luminosity appears near the blowpipe tip. This luminous zone is not clearly defined. The flame is still of abnormal size, is streaky in appearance, and a brilliant white. The

extent of the reducing or carbonizing action of the flame is judged practically by the size and definition of the luminous zone. When the luminous zone becomes more clearly defined and takes the form and color of a bluish white incandescent cone or pencil, the streakiness is diminished and the flame approaches neutral. The reducing flame is used to some extent on certain alloy steels, aluminum, and non-ferrous alloys.

Neutral or Normal Flame.—When acetylene and oxygen are ignited in the correct proportions a neutral flame is produced. The appearance of this flame is characteristic. It is made up of a distinct and clearly defined incandescent pencil or cone of bluish green in color, surrounded by a faint purplish yellow secondary flame or envelope of bushy appearance. The incandescent pencil or cone may be from ¼″ to ⅝″ in length, and is usually rounded or tapered at the ends. The maximum temperature of the oxy-acetylene flame is ⅛″ to $\frac{3}{16}$″ beyond the extremity of this jet. In establishing a neutral flame the jet should be of the maximum size for the particular blowpipe head in use. This flame is established by gradually increasing the oxygen supply until the point at which the incandescent jet is of the greatest clearness is just passed, and then finally adjusting by decreasing the oxygen supply until the desired condition is obtained.

This type of flame is the one most extensively used, and no welder is proficient until he is thoroughly familiar with its appearance and distinguishing characteristics.

Oxidizing Flame.—When an excess of oxygen exists in the welding flame it is called oxidizing. The effect of too much oxygen is to diminish the size of the flame, blunt or blur the incandescent cone, and produce a weak, streaky or scattering flame. The oxidizing flame has neither the size nor the illuminating qualities of the reducing flame, but the incandescent flame is slightly more pronounced. It is a pale violet color. In some blowpipes the incandescent cone is not only diminished in size, but is slightly bulged at its extremity as compared to the normal flame.

It is rare that a welder has occasion to use this type of flame, and hence he should be particularly careful regarding its use.

MANIPULATION OF BLOWPIPE.

The blowpipe must be grasped firmly in the hand. It is not good practice to hold it in the fingers, because it is impossible to manipulate the flame with as great regularity and control, nor will it be possible to do as heavy work without tiring.

Occasionally the hose is thrown over the man's shoulder. In this case the weight of the blowpipe is suspended and held by the tubing, so that it is only necessary to impart the typical welding motion to the blowpipe, which can usually be done by the fingers. The movement of the welding flame is hindered, however; and this method is therefore not recommended, and should be used only as a relief when the work is of long duration and the operator's wrist and forearm become tired.

The head of the blowpipe should be inclined at an angle of about 60° to the plane of the weld, as in Fig. 688. The inclination of the head should not be too great, because the molten metal will be blown ahead of the welding zone and will adhere to the comparatively cold sides of the weld. On the other hand, the welding head should not be inclined too near the vertical, because the preheating effect of the secondary flame will not be efficiently applied.

There are certain cases, however, where the conductivity of the metal is such that it is not necessary to utilize this preheating. Also certain metals have the property of absorbing the gases of this flame. Consequently, in these

cases it is best that the flame impingement be concentrated to as small an area as possible.

The motion of the blowpipe should be away from the welder and not toward him, as closer observation of the work can be obtained and greater facility in making the weld will be experienced.

Where thin sheet material is being welded and it is not necessary to use a welding rod or wire, a weld may be produced by moving the blowpipe in a straight line. It can readily be seen that this does not apply to welds which have been bevelled, and which require the use of filling material, for in this case a swinging motion must be imparted to the blowpipe to take in both edges of the weld and the welding wire at practically the same time.

In comparatively light work a motion is imparted to the blowpipe which

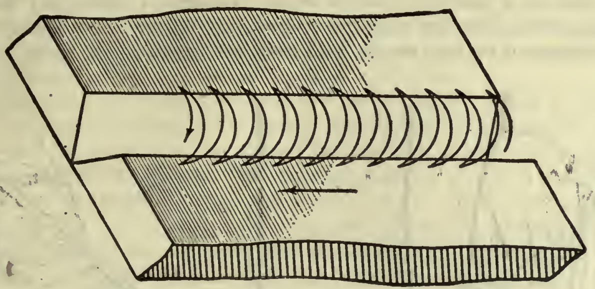


Fig. 689. Blowpipe motion.

will cause the incandescent cone to describe a series of overlapping circles, the overlapping extending in the direction of the welding. In order that the weld be of good appearance this must be constant and regular in its advance. The width of this motion is dependent upon the size of the material being welded and varies accordingly with the nature of the work.

In heavier work, if the above system were used, a great deal of the motion would be superfluous. Consequently either an oscillating movement, or one in which the jet of the blowpipe will describe semi-circles, should be used (Fig. 689.) This confines the welding zone; and while the progress is not so fast, it is more thorough than the other system for this class of work.

To the average beginner the regular control of these motions is difficult, and considerable practice is required to become skilled. It is the regularity of these motions that produces the characteristic even-rippled surface of good autogenous welding. The progress of a welder and the quality of his work can be determined to some extent by the skill with which he produces this effect.

After the swinging motions of the blowpipe have been mastered, the next step will be to introduce the welding rod into the weld in such a manner that the regular advance of the blowpipe will not be hindered nor retarded. It can be seen that there is quite a little attention needed to secure perfect cooperation between the two hands, one controlling the blowpipe and the other adding the welding rod.

The welding rod should be held and inclined as shown in Fig. 690. In this position sufficient quantity of metal may be added at the right time. With the welding rod held in a vertical position or horizontal, the possibility of the addition of an excess of metal, part of which is not fused, is great. In adding this metal, care must be exercised that the edges of the weld are in the proper state of fusion to receive it. If the metal is not sufficiently hot, the added material will merely stick to the sides and fusion will not exist. It is therefore

necessary that, by the motion of the blowpipe, fusion be produced at the edges of the weld equal with that of the welding rod.

The usual faults of the beginner are failure to introduce the welding rod at the proper time into the welding zone, to hold the rod at the wrong angle, or to fuse either too little or too much of the rod. The filling material when melted should never be allowed to fall into the weld in drops or globules. When the proper time arrives to add it, the welding rod is lowered into the weld until it is in contact with the molten metal of the edges. When in this position the flame of the blowpipe is directed around it, and thus fusion is produced.

It is customary to add metal in excess to that of the original section.

There are several very important reasons for doing this. First, the weld is reinforced and the strength is accordingly increased. Second, in case a finished surface is desired, a sufficient stock must remain to allow for finish. Third, small pinholes or blowholes may be found just under the surface of the weld, which do not extend to any depth, and may be removed by filing or machining.

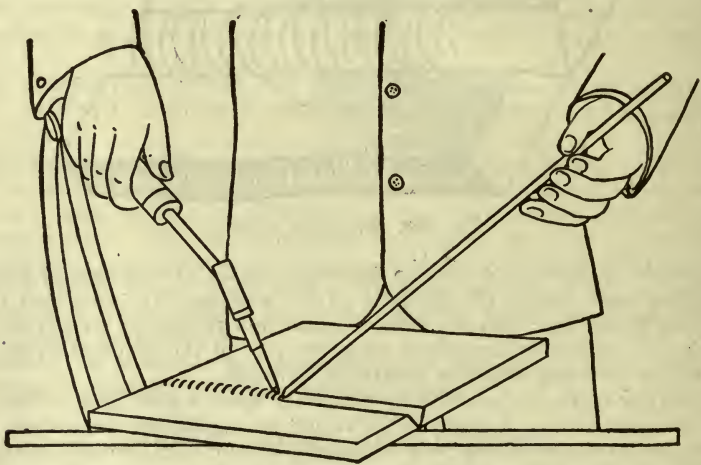


Fig. 690. Welding rod position.

SOURCES OF TROUBLE.

The first source of trouble in making a weld is improper adjustment of the welding flame. If the flame is not adjusted properly the resultant weld will be inferior. The commonest fault is the presence of too much oxygen. In this case, unless the welder takes a great deal of care in removing the oxide by mechanical means, it will be incorporated throughout the weld. The presence of oxide prevents the thorough blending of the metal, and therefore decreases its strength.

Failure to penetrate to the bottom of the weld is the cause of a great many defects. This fault is not only that of a beginner, but also the skilled operator. Very often the desire to complete a weld rapidly will cause the operator to hasten over the most important part of his work, which is to secure the absolute fusion of the edges at the bottom of the weld, before the filling rod is added. This defect not only reduces the section of the weld, but also produces a line of weakness in case the weld is submitted to bending or transverse strains.

When molten metal is added to metal which is not in fusion, a weld is not

secured. The molten metal merely sticks to the cooler metal; this defect is common with careless operators. It may be caused by improperly bevelling the pieces to be welded, by the faulty manipulation of the blowpipe, or by improper use of the welding rod.

For the beginner it is at first difficult to distinguish the proper temperature at which to add the filling material. Usually he applies the filling rod before the edges of the weld are in fusion. The adhesion in this case occurs at both edges. Occasionally one edge of the weld is in fusion, but the other is not, in which event the adhesion is restricted to one side.

In some cases the edges of the weld are both at a point of fusion too soon. Under these conditions a film of oxide may exist on each edge. When a filling material is added, adhesion is produced with a film of oxide separating the edges and the added material. Quite often an operator in applying the welding rod to the weld will concentrate his flame on the welding rod and the edges of the weld. As he plays the blowpipe around the rod he will inadvertently force some of the molten metal ahead. The metal is not in the proper state of fusion, so there will consequently be a small area of adhesion.

In welding cast iron, copper, and to some extent steel, a very common fault of the beginner is that of forming blowholes or porous sections in the weld. This can be overcome by close observation of the work while welding and by certain corrective means, the principal one of which is the use of proper fluxes and proper manipulation of the welding rod. It is needless to say that the existence of this defect in a weld seriously affects its ultimate strength.

Occasionally welds are encountered in which dirt or some foreign material is incorporated. This will cause porosity and an inferior weld, which could readily have been avoided by removing the material either before or during the execution of the weld.

STEEL.

Steel is one of the purest forms of iron. It can be molded, forged, or drawn to any desired shape. It usually contains about 98 per cent or more of iron. The principal constituent of steel, after iron, is carbon. It is present from almost nothing up to 1.50 per cent. As in cast iron, the carbon plays an important role in the properties of the metal.

Wrought iron is almost the same as a very low carbon steel. It is never cast, but is always forged. The process of its manufacture is different, however, in that it is finished in a pasty rather than liquid condition, and there is always 1 to 2 per cent of slag present in it. From the standpoint of welding, it can be considered as a mild steel.

Carbon is dissolved in the steel. It is never free as graphite. The carbon exerts a hardening effect on the metal, which increases with the carbon content. Carbon also increases the tensile strength up to about 1.20 per cent, where it begins to lower it. The ductility decreases very rapidly from 5 per cent to 15 per cent carbon. From there on the decrease is more gradual.

Silicon has very little effect on the strength of steel. Its principal property is that of producing soundness.

Sulphur lowers the strength and ductility of the metal. It also produces "red-shortness," which causes checking during the working or casting of it.

Phosphorus produces brittleness and weakens the metal with respect to shock or vibrating stresses. Manganese increases the tensile strength of steel when it is present above .4 per cent. Its effect is dependent upon the amount of carbon present.

Oxide of iron does not have any great effect on the strength of steel, but does affect its ductile properties.

Welding of Steel.—Steel melts at 2500-2700°. When molten it is not

extremely fluid. At dull red heat it begins to oxidize rapidly. The oxide, which melts at a temperature of several hundred degrees below that of the metal, remains at the surface and can be easily removed. A flux is not necessary. Close attention must be paid to its removal, however, for its presence is very harmful. It is a common fault to have layers of oxide in the weld, which cause a laminated structure that weakens the weld seriously.

Steel does not melt rapidly. It gradually comes to fusion, confined to small areas. Because of this, the weld is made up of small overlapping layers. The strength of the weld depends greatly on the thorough bonding of these layers to each other and to the bevelled edges of the piece being welded. It is a common fault to force the metal ahead of the welding area and allow it to adhere to the cold sides of the bevelled edges. This should be avoided, as a weld is not produced.

A welding rod of pure iron wire is generally used. Occasionally a nickel steel rod is used with good results on such work as crank shafts, etc. A mild steel rod is particularly satisfactory on steel castings.

Thickness of Steel	Diameter of Welding Rod
1/8″	1/16″
1/4″ to 3/16″	1/8″
1/4″ to 3/8″	3/16″
1/2″ and up	1/4″

Steel is very sensitive to the blowpipe flame. An excess of acetylene tends to carbonize the metal; an excess of oxygen tends to oxidize. Therefore a neutral flame should always be used and should be tested frequently in order that it be kept in proper adjustment.

Failures due to expansion and contraction are not numerous, because of the toughness and strength of the metal. If expansion and contraction are not properly taken care of, however, warping and buckling will surely take place, and internal strains will exist in the weld.

These can be avoided by properly setting up the work and with proper preheating methods.

The strength of a steel weld can be improved by mechanical treatment. Hammering is the most common method employed. After the welding has been completed, the entire weld should be heated to a bright red heat, and the hammering carried on at this temperature. If the hammering is done at a lower temperature, the weld will be weakened instead of strengthened.

CAST IRON.

Cast iron is hard and brittle. It cannot be rolled. It is therefore necessary that it be cast into the desired shapes. There are two general classifications of commercial cast iron, called grey iron and white iron. There is an intermediate stage known as "mottled" iron. The difference between grey and white cast is the nature or state of the carbon present. In grey iron the greater portion of the carbon precipitates as graphite. In white iron the major portion of the carbon is combined. The grey color of grey iron is due to the precipitated graphite. White iron is hard and quite brittle. Grey iron is softer and tougher.

Cast iron contains other substances, such as silicon, sulphur, phosphorus, and manganese. These all have certain effects on the properties of the iron. Silicon is used to soften the iron, since its presence aids in the forming of graphitic carbon. Manganese has the reverse effect. When present in quantities of more than .4 per cent it causes the carbon to remain in the combined state; although below this quantity it is somewhat beneficial as it counteracts the hardening actions of sulphur. Phosphorus increases the

fluidity of the molten cast iron. Above one per cent it weakens the iron. Sulphur causes the carbon to combine with the iron, thus increasing the hardness and the brittleness. It also has a weakening effect. It should never be present in quantities of more than one per cent.

Effect of Cooling.—When cast iron is melted and cooled quickly the carbon does not have a sufficient length of time to form as graphite. It remains in the combined state, which causes the iron to have a low tensile strength, to be hard and brittle. A fracture in cast iron is very smooth, close grained, and of a silvery lustre, hence it is known as white cast iron. When cast iron is cooled slowly, the carbon will form graphite. This produces a large open-grained iron which fractures with a rough granular surface. It is soft, can be readily machined, and is grey in color, due to the graphite present; hence it is commercially known as grey cast iron. Except in very rare cases where hardness is desired the aim of the welder is to produce grey iron.

Preheating.—All cast iron work should be preheated to some extent. The most important factor in the success of welds on large castings is the proper treatment by preheating for expansion and contraction.

In planning the method of welding a large complicated casting the preheating is always of primary importance. It should be carefully studied from all angles and should be thorough. There are by far more failures in the welding of this metal from haphazard methods of relieving expansion and contraction than from any other cause.

Welding of Cast Iron.—When cast iron is in fusion it oxidizes very rapidly. The oxide begins to form at a bright red heat. It melts at a temperature of 2400°-2450° Fahrenheit. Since the metal itself melts at a temperature 300°-400° F. below this, it can be seen that the oxide will not be fused at the same time as the metal. In order to break the oxide down and allow the metal to flow together a flux must be used. A properly formulated flux will dissolve the oxide and float it to the surface, so that it may be removed by scraping the molten surface with the end of the welding rod. Be sure to tap the end against something to free it from oxide before continuing to add it to the weld.

Cast iron is quite fluid when melted. For this reason it offers a little difficulty where vertical or overhead welding is attempted. Also its fluidity causes it to entrap gases, dirt, and oxide. These may be removed by proper manipulation of the blowpipe and welding rod. The molten iron can be forced ahead of the weld very easily. Adhesion to the cold metal will result, if the welding is not watched carefully.

The silicon will volatize to some extent in the molten metal. As stated above, the lowering of the amount of this constituent will seriously affect the metal. In order to compensate for this loss, a welding rod is used that contains from 2.75 per cent to 3.5 per cent silicon. The other substances such as sulphur, manganese, and phosphorus should be kept within rigid limits. The welding rod should be soundly cast, free from dirt, sand, scale, rust, etc.

The welding flame should always be neutral. The flame should be applied to the weld at such an angle that the metal will not be blown ahead. Inasmuch as the metal is quite fluid when molten, the welding is carried on in a series of overlapping "pools" or puddles. The welding rod is applied by placing it in these pools and playing the blowpipe around it. The welding is aided by continually "working" the rod in the weld in order that blowholes, dirt, scale, etc., will be forced out.

The central jet of the flame should never impinge on the molten metal. It should be held ⅛" to $\frac{3}{16}$" from it. Occasionally it is necessary to remove a blowhole, in which case the hole is burnt out with the flame and then the metal is worked over with the welding rod. The working over of a weld should be avoided unless it is absolutely necessary. If it is necessary to do this the

welding rod should be used always, for otherwise a portion of the silicon will be lost.

When the weld is finished and it is still hot, the accumulation of scale, dirt, flux, etc., on the surface should be removed by scraping with a coarse file or other tool. This is a superficial coating that, when cold, is very hard.

As soft welds are nearly always desired, the castings should be cooled slowly and evenly. Where the work is complicated or of heavy section, it is by all means best to reheat it to a good red heat and then allow it to cool.

In some cases it is sufficient to allow the casting to cool in the preheating fire, without the additional reheating.

MALLEABLE IRON.

Malleable iron is a form of cast iron. Its principal characteristic as compared to grey iron is its toughness and ability to resist shock. It is produced by annealing white iron castings in pots or boxes, packed with hammer and rolling mill scale, turnings, borings, etc., at a temperature of 1200°-1300° F. for 48-96 hours.

The castings are then cooled slowly.

During this annealing process the material in which the castings are packed absorbs the carbon from the surface of the casting. In this way the surface becomes of steely nature, while the interior retains its cast iron properties. In small castings the decarbonization may exist throughout; in the larger, a core or heart of cast iron is always present.

It can be readily seen that a fusion weld of this material is not practical, because of the variation in its composition. An attempt to weld it will produce a hard, brittle weld, full of blowholes, and of very little strength.

In order to join this metal with the blowpipe, brazing is used. The metal is heated to a bright red heat, just below fusion, and Tobin or manganese bronze is added as a filling material. A brazing flux is also used. This makes a generally satisfactory joint of this material.

ALUMINUM.

There are two general types of this metal of interest to the welder—rolled or drawn aluminum, and cast aluminum. The commercial rolled metal varies in purity from 98 per cent to 99.75 per cent, the impurities being silicon and iron. Pure aluminum is rarely used for casting purposes, because its strength is much less than that of aluminum alloyed with other metals. Zinc is the principal alloying metal, although small percentages of copper are very frequently used with it. The amount of zinc ranges from 5 per cent to 25 per cent, according to the requirements of the casting.

Aluminum has a very low melting point as compared to other metals, 1215° F. It is of high thermal conductivity and has a high specific heat. From the standpoint of welding its most important property is its combination with oxygen. Due to the action of the oxygen in the air, aluminum is always covered with a thin coating of oxide. When fused a heavy coating forms. The oxide is very refractory, melting at a temperature above 5000°. The oxide is also of a greater specific gravity than the molten metal with the result that if it is not removed it will be distributed throughout the metal.

It has a short fusion range, retaining its normal properties up to a temperature near fusion, when it becomes pasty and then passes rapidly into complete fusion. Oxidation becomes severe just previous to fusion. The metal, when molten, is quite fluid. Gases such as nitrogen, carbon monoxide, hydrogen, etc., are easily absorbed in aluminum, and if not worked out will produce blowholes and porosity.

Because of the rapid fusion and fluidity of aluminum, welding requires a little practice in order to properly control it under the blowpipe. After this is done the welding is comparatively simple.

The greatest difficulty is that of removing the oxide. On sheet aluminum work a flux should be used. The composition of this flux is usually of alkaline fluorides and chlorides. It is applied to the weld by means of the welding rod, or it is dissolved in water to either a paste or liquid and applied with a brush. This flux will react with the oxide and form a fusible compound that will float to the surface, which further serves as a protecting coating and prevents absorption of gases. The welding rod should be as pure as possible—particularly free from certain metals, such as copper, that have a tendency to set up a galvanic action in the weld.

In preparing the metal for welding, the edges to be welded and the adjacent surfaces should be carefully cleaned. In heavier sheets the edges should be bevelled. In the lighter sheets the welding will be aided by flanging them about $\frac{1}{16}''$.

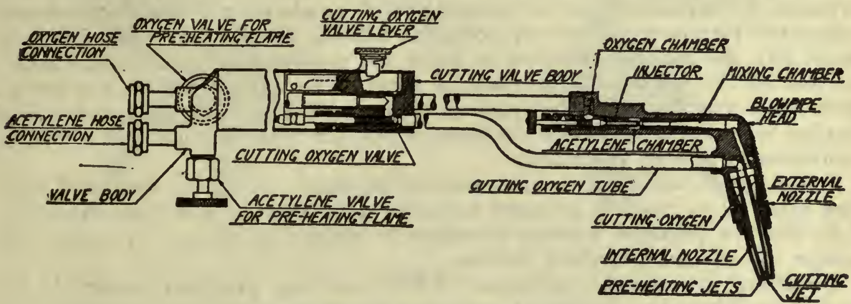


Fig. 691. Section cutting torch.

All aluminum articles should be preheated to some extent before welding. In certain cases the playing of the secondary flame on the object will be sufficient; in others a more thorough treatment is required, such as charcoal or coke.

Aluminum castings are handled a little differently from sheets or plates. As mentioned above, castings are of different composition. Since the metal has a low melting point, high conductivity, and becomes rather fragile previous to fusion, preheating and cooling must be carried out very carefully. The average aluminum casting is somewhat complicated in its design, hence the necessity of skillfulness in carrying it through the preliminary heating period.

The use of a flux on castings has been abandoned by the majority of welders. In place of it they break down and remove the oxide by means of a paddle, which is also used to smooth off the surface of the weld after it is completed.

When the weld is finished the casting should be allowed to cool very slowly and evenly.

CUTTING OF STEEL.

When a jet of oxygen strikes steel which has been previously raised to a high temperature, rapid combustion takes place at the point where the jet strikes the metal. The heat generated by the combustion and that supplied in the preliminary heating is sufficient to bring the products of the combustion (oxides of iron) to a molten condition. This slag flows out, or is blown out,

of the cut. After the reaction is started it is carried on continuously by the application of the heating source and oxygen jet.

Steel and wrought iron are the only metals that can be cut economically by this process. These two metals combine readily with oxygen, with the liberation of heat. The slag is produced at a temperature below that of the melting point of the metal, with the result that it is easily separated from it.

Other metals do not produce so much heat when combining with oxygen, and the oxide formed is not reduced to a molten condition at temperatures below that of the metal, with the result that it cannot be easily separated.

The combination of the oxygen with the iron is not that of complete combustion. An examination of the slag produced shows the presence of metallic iron, which leads to the belief that the oxidation follows the grain surfaces of the metal and more or less mechanically disintegrates the mass at the line of cutting.

Cutting Blowpipes.—A cutting blowpipe is used for applying this method of cutting. In principle the cutting blowpipe differs from the welding. In addition to the oxy-acetylene flame which serves as a heating agent, there is a separate jet of pure oxygen for bringing about combustion. This is commonly called the cutting jet. The oxy-acetylene flame is usually made up of two or more jets, the size and position of which are regulated with different nozzles or tips for the different thicknesses of metal. The oxygen for the oxy-acetylene flame and that for the oxygen jet is controlled by separate valves. The cutting jet valve is usually of the lever or plunger type, in order that it can be conveniently opened and closed.

Fig. 691 shows a low pressure cutting blowpipe. It can be used with both low pressure or medium pressure acetylene generators or acetylene cylinders. Like the low pressure welding blowpipe, it utilizes an injector to secure the proper oxygen and acetylene mixture.

Cutting is a simple operation. There are four principal factors to be considered, namely: Speed of advance; pressure; volume of oxygen; and size of preheating flame. When the cutting blowpipe is moved too fast, the oxygen does not penetrate, and the preheating flame does not have an opportunity to bring the metal up to the proper temperature. If the speed is too slow, the consumption of the gases is too high and the cost is increased. The blowpipe should be held steady and advanced at a constant rate, in order that the cut may be smooth; for if it is irregular a rough cut is produced.

In making a cut a definite volume of oxygen is required. The pressure of the oxygen should be such that it will reach the bottom edge of the metal. There are two ways of doing this, by using a small nozzle and a higher pressure, or by using a larger nozzle with a lower pressure. Of the two the latter gives the better results for average work.

The preheating flame should be of the proper size. Too small a flame retards the speed of cutting. Too large a flame not only gives a rough cut, but in some cases hinders the combustion.

JOB 240. PRACTICAL OXWELDING PROBLEMS.

Object: Job 240 is to give the student practice in the melting of metal and in running it together. The student should light the blowpipe in accordance with the directions given and establish a neutral flame. He should use a No. 4 welding head, with 11 lbs. pressure. The steel should be set at an angle as shown in Fig. 692. The student should take the blowpipe in his right hand and hold the flame on the two pieces to be welded until the metal is hot enough to run together. In doing this job, the torch should be held at an angle of about 45°. The tip of the flame should be kept about ⅛" from the metal.

When the metal commences to melt, the blowpipe should be moved by a swinging motion from side to side, so as to melt both edges together. The melting of the edges of the two pieces should be carried on by means of this swinging motion until the entire length of the joint has been covered. In making this weld, you should watch carefully the following points:

Do not run the hot metal on top of the cold metal.

Do not leave any blow holes nor scale in the weld.

Do not hold the flame on one side of the metal so long that it will burn before the other side is melted. In other words, keep the flame moving over the pieces to be welded.

When the welding has once started, carry it on continuously.

Do not stop and go back over your work.

This problem should be practiced until there is produced a sample with a clean, smooth, finished weld.

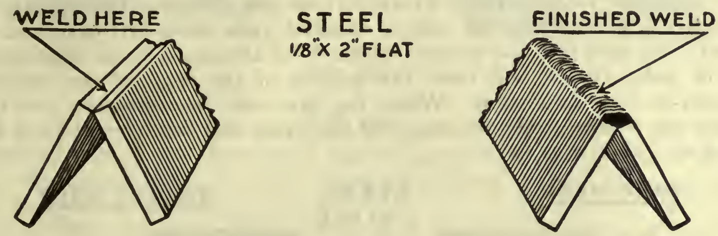


Fig. 692.

JOB 241.

The object of this job is to teach the proper method of adding the filling rod to the weld.

Take two ¼" plates and bevel them 45°. This can be done on an emery wheel or with the cutting blowpipe. The edges to be welded must be clean and free from rust, grease, scale, etc. In setting up the two plates, butt one end of the two edges together; spread the other end ¼".

Use the same size welding head and the same oxygen pressure as is used in Job 240. The filling rod is used to fill up the V made in the metal. Care must be taken to see that the rod is properly added. It is usually a rod varying in size from 3/64" to ¼" in diameter, depending on the size of the work, and 30" to 36" long. For ¼" plate a ⅛" rod should be used. The blowpipe should be held at the same angle as in Job 240. The filling rod is held in the left hand and at about 60° in front of the blowpipe. The filling rod should be held ⅛" or 3/16" in front of the blowpipe flame. After the bevel edges of the plate are brought to a welding point, the filling rod should be held down in the V in the molten metal, the flame being moved **around** the rod and not on it. This will melt it satisfactorily. In this manner feed in the welding rod to the joint until the V is built up 1/32" or 1/16" thicker than the original plates. Proceed in this manner until the joint is completed. Do not start to add the filling rod until the bottom of the V has been melted together. Do not place the cold welding rod into the molten metal. Always be sure that the welding rod is melted into metal that is already molten. Do not hold the end of the filling rod above the metal and allow it to drop into the weld. Do not add the metal from the filling rod to the cold metal of the weld. Do not force the molten metal ahead on the cold sides of the V. As in Job 240, both sides of the V should be brought up to melting temperature at the same time.

Fig. 693.

JOB 242.

Welding Heavy Steel Plate.—Take two plates 1″ in thickness and bevel one edge of each 60° on each side. These should be set up the same as in Fig. 694, that is, the bevelled edges should touch each other at one end and be ¼″ apart at the other.

The No. 15 welding head should be used with 30 lbs. oxygen pressure. Use ¼″ diameter welding rod. Proceed from one side, but see that the weld is re-enforced ⅛″. When one side is finished, turn the piece over and finish the other. Be sure that the bottom of the V of the second side is thoroughly melted in order that it will meet the bottom of the weld of the other side. This point is very important. When the first side is completed and turned over, take the welding rod and scrape off any scale that has been formed during the welding. (See Fig. 694.)

Fig. 694.

JOB 243.

To Fill up a Section of a Gear or Pinion that has had a Tooth or Teeth Stripped.—Great care should be taken, that at the beginning of the weld the metal is melted thoroughly before the welding rod is added. It is necessary that care also be taken that the shape of the tooth be followed as closely as possible, in order that the least amount of finish will be required. Refer to Fig. 695.

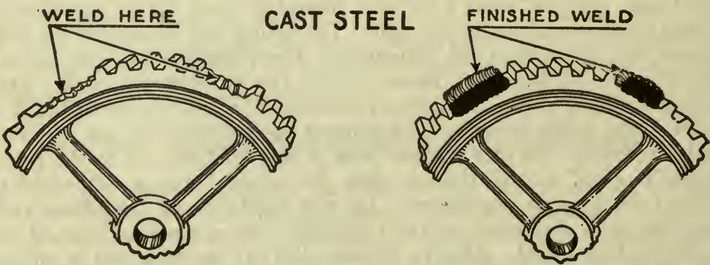


Fig. 695.

JOB 244.

Building up Lugs and Bosses.—Take a plate of heavy steel and build up a lug 1″ high. This is done in exactly the same way as any other weld, except

that care must be taken to control the metal and not let it run over the plate. Add the metal in layers of ¼″ in thickness. Then add to one corner of the plate a section of metal 2″ x 3″ x ½″ thick. This should be done without letting the metal run over the edges. (See Fig. 696.)

Be sure that a good weld is obtained at the beginning and that each layer is thoroughly welded to the next. If a good weld to the surface of the plate is not first obtained, the rest of the work is worthless.

Do not hold the blowpipe too long in one place. Keep it always in motion; otherwise the metal will run down on the sides. Be sure that all scale and dirt are worked out of the metal.

Fig. 696.

JOB 245.

Welding Cast Iron.—Prepare a sample with a 45° bevel. Place the two beveled edges together. Use a No. 12 head with the proper oxygen pressure. Use ¼″ cast-iron filling rod.

Cast iron is always welded with a flux, which is a chemical compound added with the filling rod to prevent oxidation and to remove impurities. But in order to show the purpose of a flux, the sample should be welded first without it.

The welding flame should be pointed the same as before in welding steel; but after the metal has commenced to melt, the rod should be put in the molten metal and the blowpipe should be swung from one side of the V to the other. Cast iron cannot be welded in layers like steel. It should be carried on in molten puddles. The welding rod should be held in this molten metal and worked in by rubbing the rod against the sides of the V. This rubbing of the rod against the sides of the V works out to the surface any sand or impurities that may be in the metal.

It will be noted that the metal is covered with a scale or coating that is difficult to remove. The use of the flux will aid in removing this coating.

After this job is completed another sample should be prepared in the same way. This time the student should carry on the welding exactly as before, except that a flux or scaling powder will be used. This application is made by dipping the hot welding rod into the flux, a small quantity of which will stick to the rod. When the rod is inserted into the weld, this will melt off. The flux should be added to the weld whenever scale or sand or dirt appears. Too much flux should not be used as it would have a bad effect on the weld.

The rod should be kept in motion as described by rubbing it along the sides of the weld, and the weld carried on with little puddles of melted metal. Sand, scale, and blowholes should be worked out of the melted metal by means of flux and motion of the rod. Whenever a white spot appears in the melted metal, it is either scale or sand or some other impurity. If it is allowed to remain in the weld, it will form a blowhole. When this white spot is noticed, it should be taken out with the rod and removed from it. Whenever this dirt is left on the rod it will be put back in the weld, just as soon as the rod is applied again. Cast-iron welding should be carried on continuously as fast as

possible until the job is completed. If it is absolutely necessary to go back over the weld, always add metal from the filling rod. A cast iron weld should be solid all the way through, and should be soft so that it can be machined. If a good cast iron welding rod is used, it will help the weld to be soft. All cast iron welds will be hard if they are not cooled slowly. Just after the weld has been finished and it is still at a bright-red heat, scrape off the surface to remove the flux, scale, and dirt that have been worked out of the metal. If this is not done the weld will have a very hard surface, notwithstanding the fact that it might be soft underneath. This scraping can be done by a chisel, the blunt end of a file, or a piece of flat scrap iron.

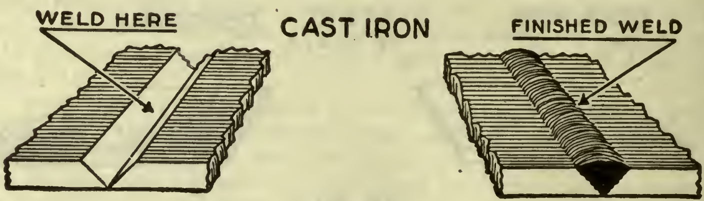


Fig. 697.

JOB 246. WELDING AUTOMOBILE CYLINDERS.

The object of this problem is to give practice in the welding of automobile engine cylinders.

For this problem a block of two cylinders should be used. The first break to be repaired is in the water jacket, as shown at 698A. The second break is on the flange, as shown at 698B, and the third is on the water jacket, as shown at 698C. The fourth, 698D, is a crack on the head of the cylinder, extending from a spark plug thimble over the dome to the bore of the cylinder. If any

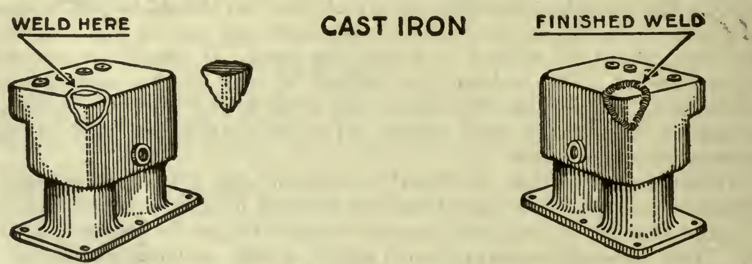


Fig. 698A.

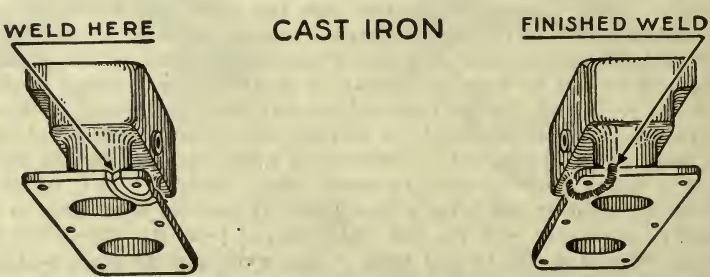


Fig. 698B.

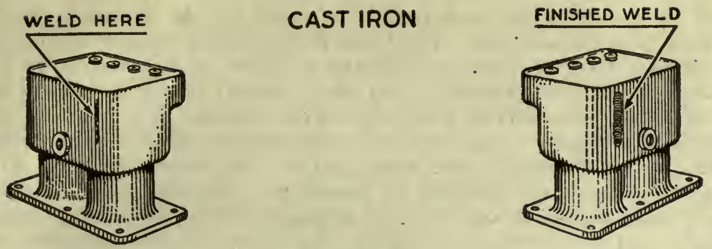


Fig. 698C.

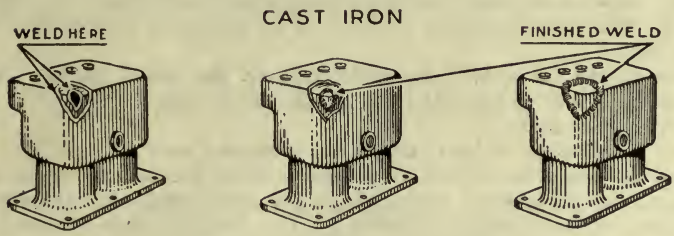


Fig. 698D.

of these were welded cold the casting would break from expansion, when the flame were applied to it, and from contraction after the weld had been made.

In order to overcome this, it is necessary to preheat the cylinder. To do this build a little furnace around it by means of fire brick. (See Fig. 699.) In order to give this furnace draft, the bottom row of bricks should be placed 1″ apart. The cylinder should be placed on this little furnace with the bore up and the head of the cylinder resting on two bricks. The furnace should be so built that there are 6″ between the walls and the cylinder. There should be space enough to allow the cylinder to be turned in the fire without knocking down the walls of the furnace when it is time to weld. About three shovels of charcoal should be placed around the cylinder at first, and a little kerosene put on it before it is lighted. After the charcoal has become thoroughly lighted, and the cylinder has become slightly heated, more charcoal should be added until half the casting is covered. Then a piece of asbestos should be placed over the top of the furnace and a few holes punched in it to allow for draft. Leave the cylinder in the furnace until it is brought up to a dark-red heat. Then turn the cylinder up so that the part to be welded can be easily reached. Then replace the asbestos sheet and cut a hole in it so that the cylinder can be

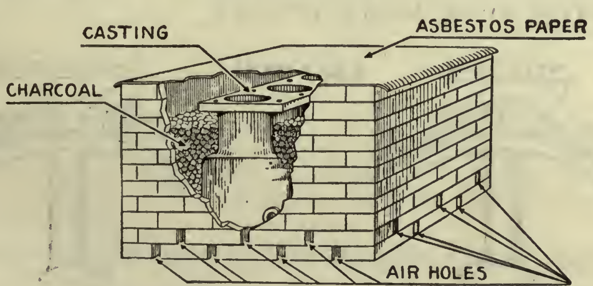


Fig. 699.

reached by the blowpipe and rod. The crack in the cylinder should have previously been chipped out. Weld this crack exactly as described before, but use a smaller size welding head—either a No. 6 or No. 7. Never take the cylinder out of the fire to weld it. Never let the fire go out during the welding. After welding, add more charcoal to bring the cylinder up to an even heat, and leave it in the furnace to cool slowly. Care must be taken that the metal does not run through to settle in the water jacket. Be sure to work out all dirt or scale, and not leave any pinholes or blowholes. In order to prevent the bore of the cylinder from scaling, before it is placed in the preheating furnace give it a slight coat of oil and then apply a thin coating of flake graphite, which is a form of carbon. This is done by taking the graphite in the hand and throwing it against the oily side of the bore, which will cause it to stick. After welding is finished, this can be cleaned off by means of a piece of a rag or a piece of waste.

Crack B can be welded by preheating in the same manner. It is not necessary, however, to preheat it so much. It is only necessary to heat the cylinder to a blue heat.

Crack C should be welded exactly the same as Crack A.

Crack D should be treated a little differently, because the crack is on the inside of the water jacket. A portion of the outer wall, over the crack, must be removed. This is done by drilling. The crack is then chipped out and placed in a preheating furnace, exactly as described in A, and the welding is carried on in the same manner. When the weld is finished, and the casting is still hot, the removed portion is placed back into the outer jacket and is welded in. In order to hold this patch in position while it is being welded, a piece of cast iron rod is welded to it, which serves as a handle.

After the patch has been welded in, this rod or handle can be cut off. The reheating should be carried on as in Crack A and the casting also cooled slowly.

After the cylinder has been welded and is cooled off, it should be tested to be sure that the weld is entirely tight. Where it is possible, this should be tested with water pressure. If it is impossible to do this, the water jacket should be filled with kerosene, because kerosene penetrates a crack or a pinhole faster than water.

In case any leaks are found, the metal should be chipped out at that point, placed in the fire, and rewelded exactly as before.

JOB 247.

Building up of Teeth on Cast Iron Gears or Pinions.—The proper welding head and filling rod should be selected according to the chart. If the gear is a light one—that is, the face not more than three inches in width and the rim not more than one inch in thickness—the job can be done without preheating. Heavier than this the job should be preheated.

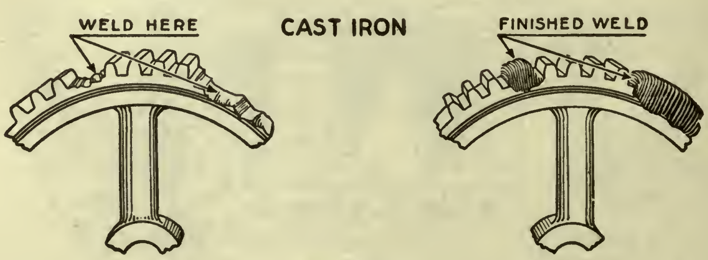


Fig. 700.

The preheating should be done with a charcoal fire.

In doing a job of this kind the greatest care should be taken to start it properly. The metal on the rim of the gear to which the tooth or teeth should be added must be first melted thoroughly. The welding rod is then added. It is necessary to control the metal so that the least amount of machining or finish is required; the tooth can be built up by using carbon blocks that have been shaped out to fit between the good teeth. If these carbon blocks are shaped and placed properly, the tooth when added with the blowpipe will require very little finish or machining.

Care must be taken that the tooth is built up fully and that a little metal extends over each end. This extra metal can later be removed by filing. To add this extra metal the blowpipe flame should be held at the side of the tooth; that is, on the edge of the rim the direction of the flame should be horizontal. This is to keep the metal from running down on the side.

In order that the tooth may be machined if necessary to insure a finished product that will not be brittle and crack off when used, the weld must be cooled slowly.

JOB 248.

Welding Cast Aluminum.—Cast aluminum is usually a little different from sheet aluminum, because it has zinc and other metals in it. A flux should not be used on cast aluminum. The oxide should be scraped out by means of a paddle as the weld progresses. A paddle such as used is made of a piece of one-fourth inch iron rod with the ends flattened down so that it is about three-eighths inch wide. This flat end should be ground smooth.

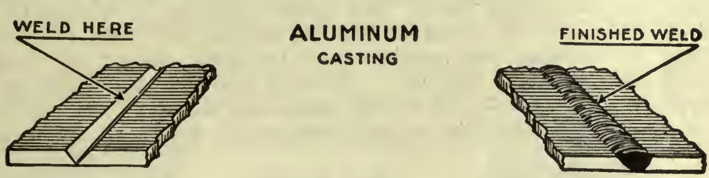


Fig. 701.

In welding an aluminum casting the flame is played on it until it is melted. The metal is now brought together by use of the paddle. It is done by working the paddle in the metal similarly to the way in which the cast iron welding rod is used in working the impurities out of a cast-iron weld. The paddle breaks down the oxide which is on the melted aluminum and which would prevent it from running together. After the weld is started the paddle is laid aside and the welding rod added. The entire thickness of the plate should not be filled up by means of the welding rod at one operation. After the V has been about half filled the welding rod is laid down and the metal worked with the paddle. This is to insure a proper weld at the bottom of the V, and the sides. Then fill up the weld to the proper thickness and smooth off with the paddle. Always reinforce the weld with sufficient metal so that it can be cleaned off. Never start an aluminum weld, particularly cast aluminum, unless there has been a certain amount of preheating. In some cases playing the blowpipe on both sides of the weld will be sufficient; in others the preheating must be handled more carefully.

JOB 249. WELDING AN ALUMINUM CRANK CASE.

The object of this problem is to give practice in the welding of aluminum castings, such as a crank case as shown. Assume that there are three breaks in this crank case—A, B, C, Fig. 702.

Break A.—This is a simple break. The crank case and parts to be welded are placed in position for welding. The case and arm should be lined up with straight edges, and the arm clamped onto the body of the crank case by means of a screw clamp.

The arm and case are preheated lightly either by means of a light charcoal fire or gas burner, as shown in the figure. The bearings of this crank case are usually babbitted. If the welding is not too close to a bearing, it can be protected by inserting wet asbestos in it and keeping it wet throughout the weld. If the bearing or bearings are too close to the weld, they should be removed. The casting is preheated until it begins to sweat, which is shown by pimples or "bubbles" of metal appearing on the surface. The proper preheating temperature can also be told by scraping with the paddle. When the temperature is such that the metal can be scraped off with the paddle it is ready to weld. Select a proper size welding head, which should be about one size smaller than that used for steel. When the casting is not preheated, which will rarely be the case, the same size welding head as used for steel should be used. Use a one-quarter inch drawn filling rod in order to give good alignment of the pieces. They are not beveled. It is therefore necessary to start the weld by applying the flame and scraping at a V with the paddle. The V is scraped out as the weld progresses. When an aluminum casting of this kind is heated up for welding it is not possible to turn it, and it must remain in its clamps and on straight edges. Vertical, horizontal, and in some cases overhead welding, must therefore be used. Because of the difficulty in going over a weld in cast aluminum after it has once been made, the paddle and flame are applied to the under side of the weld from time to time as welding progresses—to remove any excess metal that hangs there. The proper amount of reinforcing must be added to allow for the usual finish. In making the weld the methods of handling the welding rod, paddle, and blowpipe should be employed as described in Job 248.

Break B.—This break is in the rib supporting the crank shaft bearing. For this job the crank case is set up and arranged as for break A. A small pre-

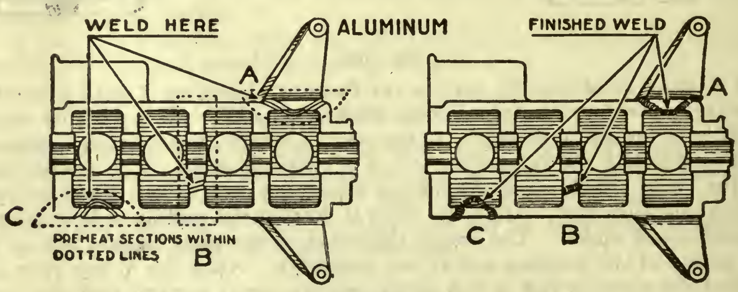


Fig. 702.

heating fire of charcoal is built around the casting; during the preheating period the welder must watch his fire carefully to see that the casting does not become overheated. It should be brought to the same temperature as in break A. During the preheating and welding the case should be covered with asbestos paper so that it is protected from draughts. The welding should be done the same as in break A. In a break of this kind slow and even cooling is absolutely necessary and should be very carefully carried out. The casting should not be subjected to any draughts or any change in temperature.

Break C.—This break represents a piece broken from the side of the crank case. The crank case and broken parts are lined up as described for A, and the

broken piece fitted into the hole. A preheating fire of charcoal is built and covers the area shown. The same precautions in preheating should be observed as in A and B. The welding and cooling is carried on in exactly the same manner.

If two or more ribs in the center of the casting similar to break B were broken, it would be necessary to reheat the entire casting and carry the job on as described.

JOB 250.

Brazing Malleable Iron.—It is not possible to weld malleable iron, because when it is melted it loses its malleable properties. For this reason the best way to handle a job of this kind is to braze it. The parts to be joined should be beveled to 60°. Where it is possible to apply a reinforcing to the joint, it is sometimes not necessary to V it out. Bring the pieces to be welded to a cherry-red heat by means of the welding blowpipe. If the casting is large, this preheating may be helped by means of a light gas blower or flame. Use a $\frac{3}{16}''$ or $\frac{1}{4}''$ Tobin or manganese bronze welding rod; heat and dip it into the flux, then add the flux and the rod into the V as fast as it will melt in. Fill up the entire V for a short section by means of the rod, alternately dipping the rod into the flux before going ahead. In other words, do not run a thin stream of metal in the bottom of the V and go back over the weld and fill up in that manner. Always add metal so that the reinforcement of at least an eighth of an inch is secured; never less than this. When the brazing is finished it should be covered up with asbestos and allowed to cool fairly slowly. Do not heat the edges of a malleable casting to a melting heat; never get them above a cherry red. Be sure that enough flux is applied to keep the edges of the casting clean. Always use a good grade of bronze rod. Soft brass wire will not do.

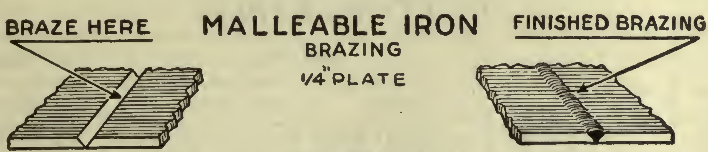


Fig. 703.

JOB 251.

Brazing a Heavy Steel Part to a Light Steel Part.—A thin tube and a half-inch flange is a representative problem. A good braze will not only give a fillet at the joint of the flange to the tube, but the brazing will extend down the tube and give contact between it and the flange. To do this it must be heated properly. The flange should be brought to a red heat by means of the blowpipe. The blowpipe should be applied to the flange only during this operation. It is not necessary to direct it to the tube. After the flange has reached a good red heat, add flux and brazing wire. Always be sure to use plenty of flux, as it is necessary that both parts must be kept clean during the brazing.

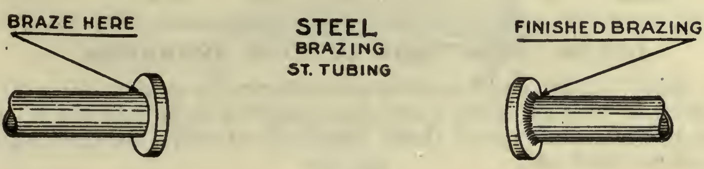


Fig. 704.

OXY-ACETYLENE CUTTING.

Connecting the Cutting Blowpipe.—The cutting blowpipe is connected exactly the same as the welding blowpipe, the only difference in the apparatus being that a heavier regulator for the oxygen cylinder is used and the hose from this regulator to the blowpipe is heavier. This is because a heavier pressure is usually employed in cutting. This refers only to the oxygen pressure, however, because the acetylene pressure is never higher than in welding.

After the apparatus is connected exactly in the same method and in the same order as the welding blowpipe, the oxygen cylinder valve and the acetylene cylinder valve are opened. Refer to the table on this page for the proper oxygen pressure to be used for the particular thickness of steel to be cut. Then establish this pressure with the cutting valve open. Be sure not to adjust this pressure with the cutting valve closed.

The cutting blowpipe is made a little different from the welding blowpipe, there being several holes surrounding a larger central hole in the nozzle. From the smaller holes issues an oxy-acetylene flame that is used for preheating. From the central hole issues a jet of pure oxygen for cutting. There are three valves on the blowpipe; one valve controls the acetylene, another valve controls the oxygen for the heating flame and the third valve is used to control the cutting oxygen. The first two valves are regulated exactly as welding blowpipe valves, because they must produce a neutral flame in the preheating jets. These jets are used to heat the steel so that the central jet of oxygen will burn through the steel.

After the heating flames have been adjusted with the cutting oxygen valve wide open, the cutting oxygen valve is closed, leaving the heating flames only burning. The student is now ready to begin cutting.

CUTTING TABLE

Thickness of Metal In	Size of Nozzle	Oxygen Pressure Lb. Per Sq. In.	Per Hour				Per Linear Foot	
			Speed		Gas Consumption		Gas Consumption	
			Machine Lin. Ft.	Hand Lin. Ft.	Oxygen Cu. Ft.	Acetylene Cu. Ft.	Oxygen Cu. Ft.	Acetylene Cu. Ft.
1/8	No. 1	10	120	90	28	7.8	0.31	0.09
1/4		15	93	74	37	11.3	0.50	0.15
3/8		20	81	62	48	14.2	0.67	0.23
1/2		25	73	55	58	16.3	1.05	0.30
3/4	No. 2	25	63	46	80	19.7	1.74	0.43
1		30	57	40	100	22.0	2.50	0.55
1 1/4		35	53	36	120	23.6	3.33	0.66
1 1/2		40	50	33	141	25.3	4.27	0.77
2		50	46	29	184	27.7	6.34	0.96
3	No. 3	55	41	24	268	31.9	11.2	1.33
4		65	36	20	352	35.6	17.6	1.78
5		75	32	17	436	38.8	25.7	2.28
6		85	29	15	522	41.5	34.8	2.76
8	No. 4	95	23	11	698	46.2	63.4	4.2
10		115	18	8	880	50.3	110.0	6.3
12		135	15	6	1080	53.9	180.0	9.0
14		155	12	4 1/2	1290	57.3	287.	12.7
16		175	10	3 1/2	1520	60.4	434.	17.3
	Rivet Nozzle	40	....	....	240	25.0		

JOB 252. PRACTICAL CUTTING PROBLEMS.

The object of this problem is to give practice in cutting 1/2" steel plate. Take a piece of plate and draw a line on it, which is to be followed in cutting. This line should be made with chalk, soapstone, or center punched marks, so that it will not burn off.

Place the preheating flames of the blowpipe, which has been lighted in accordance with the instructions previously given, to the upper edge of the plate, at the point where the cut is to be started. The preheating flame should be so placed that about ⅛″ of the metal from the edge is heated. This should be brought to a bright-red heat. When this temperature is reached, the cutting jet is turned on by means of the cutting valve. It will immediately burn out

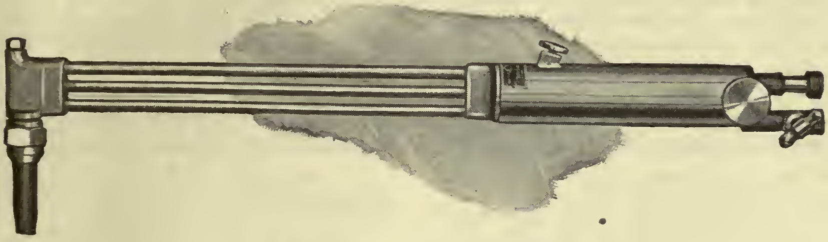
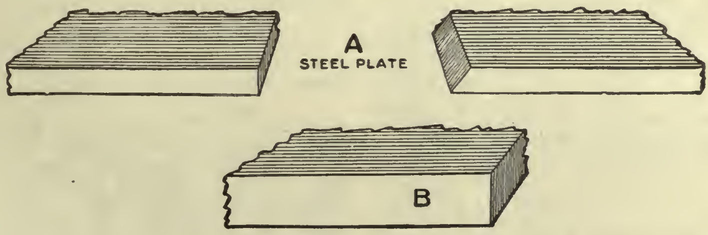


Figure 705. Cutting blowpipe.

the steel, which will be shown by a great number of sparks and melted slag dropping from the plate. The blowpipe is then moved along the line previously marked out, at a speed which will allow the oxygen to burn the steel out clear through along this line. This speed will come by practice. If the blowpipe travels too fast, the metal will not be heated fast enough, and therefore the oxygen will not cut it. If the blowpipe travels too slowly, the benefit of the heat from the burning metal will be lost.

After the cut has been started, the preheating flame should be carried so that the tips of the flame will just reach the plate. After skill has been acquired, it will be possible to carry the flame ⅛″ or ¼″ from the plate. The student should practice on the plate until he has mastered the fundamental principles of cutting. After he has succeeded in making a cut, he should try to produce as smooth and as fast a cut as possible. For smooth cutting, there are three points to be watched. First, the preheating flame should be kept as small as possible. Second, the oxygen pressure should be kept such that it will blow the slag clear through but will not be excessive. The speed of cutting should be constant and regular and should be as fast as is possible for the oxygen to burn the metal out. If too large a preheating flame is used the top edges of the plate will be melted down. Do not use an oxidizing preheating flame; this will also cause the edges to oxidize and melt. Do not hold the preheating flame too far from the cut, because the cut will not be continuous and the efficiency



CUTTING

Fig. 706.

will be lowered. If the preheating flame is held too close to the plate, the edges will be burnt. Where smoothness is necessary, the preheating flame should be held so that it is almost vertical. Where speed is required, the blowpipe should be held so that the preheating flame will travel ahead. This angle should be 60° on light plate.

In cutting a plate, the left hand should grasp the blowpipe about 6″ from the head. Because of the heat that will be reflected, the student should wear an asbestos glove on this hand. The right hand should grasp the handle on the blowpipe so that the thumb or finger will be in contact with the cutting valve. In order to make a smooth cut, it is necessary that the hand be steadied. This is done by resting the left hand on the plate. The smoothness of the cut depends on the steadiness with which it is carried on. When it is necessary to make a bevel cut, the same method is used as described above, except that the blowpipe is held so that a cut is made on an angle to the surface of the plate.

INDEX

T H UDEC

JUN 11 '84

THIS BOOK IS DUE ON THE LAST DATE STAMPED BELOW

RENEWED BOOKS ARE SUBJECT TO IMMEDIATE RECALL

MAR 1 6 1968
MAR 1 REC'D

UCD LIBRARY
DUE APR 1 6 1970

APR 1 3 REC'D
REFILED PSL

APR 23 1992

FEB 02 1995
REC'D FEB - 5 1995

RECEIVED
FEB 0 6 1995
PHYSICAL SCS. LIBRARY

LIBRARY, UNIVERSITY OF CALIFORNIA, DAVIS

Book Slip–14,800-8,'66(G5531s4)458

50
net

UNIVERSITY OF CALIFORNIA, DAVIS
3 1175 01909 3023

383 TL145
K8
Kuns
Automotive trade training.
P. E. Reserve JUN 1 9 1930
NOV 2 3 1932
NOV 2 5 1932 W. O. Williams
NOV 8 1959

PHYSICAL
SCIENCES
LIBRARY

TL145
K8

383

UNIVERSITY OF CALIFORNIA LIBRARY